DOCUMENT RESUME

ED 055 609 LI 003 163

TITLE	The Application of Computer Technology for Development.
INSTITUTION	United Nations, New York, N.Y. Dept. of Economic and Social Affairs.
PUB DATE	71
NOTE	122p.; (28 References)
AVAILABLE FROM	Sales Section, United Nations, New York, N.Y. (E.71.II.A.1 $2.00)
EDRS PRICE	MF-$0.65 HC-$6.58
DESCRIPTORS	*Computers; *Computer Science; *Developing Nations; *Economic Development; International Organizations; International Programs; *Social Development
IDENTIFIERS	United Nations

ABSTRACT

At its twenty-third session, the General Assembly adopted resolution 2458(XXII) requesting the Secretary-General to prepare a report giving special consideration to the situation of the developing countries with regard to: (1) the results already obtained and the needs and prospects for the use of electronic computers in accelerating the process of economic and social development; (2) the various forms which international action may take to intensify cooperation in the field of computers and (3) the role the United Nations can play in promoting international cooperation in that field with emphasis on questions concerning the transfer of technology, the training of personnel, and technical equipment. The report is presented in two parts: Part One discusses programs for developing countries and Part Two deals with caveats, barriers and incentives with respect to computer technology for development. The principal conclusions and recommendations drawn from this report are included. (Author/NH)

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the application of computer technology for development

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UNITED NATIONS
New York, 1971

126p.
28 Ref.

LI 003 163

1/2

NOTE

Symbols of United Nations documents are composed of capital letters combined with figures. Mention of such a symbol indicates a reference to a United Nations document.

E/4800
ST/ECA/136

UNITED NATIONS PUBLICATION
Sales No.: E.71.II.A.1

Price: $U.S. 2.00
(or equivalent in other currencies)

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INTRODUCTION

General

1. At its twenty-third session, the General Assembly adopted resolution 2458(XXIII) requesting the Secretary-General to prepare a report giving special consideration to the situation of the developing countries with regard to:

(*a*) The results already obtained and the needs and prospects for the use of electronic computers in accelerating the process of economic and social development;

(*b*) The various forms which international action may take to intensify co-operation in the field of computers;

(*c*) The role which the United Nations can play in promoting international co-operation in that field, with emphasis on questions concerning the transfer of technology, the training of personnel and technical equipment.

2. A number of activities were undertaken in connexion with the preparation of this report. The Secretary-General sent a letter and questionnaire to Governments of Member States inviting them to provide him with relevant information in connexion with the above-mentioned resolution (see annex IV). Replies were received from fifty-one Governments. Organizations in the United Nations family were invited to co-operate by responding to a letter seeking their views and experience. This was followed up by visits by consultants to the Headquarters of each interested organization for discussions with their staff. Other relevant organizations in the field of computer technology were also approached and invited to provide information and their views. A number of the important international professional organizations were invited to put forward their comments and views and they co-operated closely with the Secretary-General in the preparation of this report.

3. Pursuant to the resolution the Advisory Committee on the Application of Science and Technology to Development (ACAST) assisted the Secretary-General, and established an *Ad Hoc* Working Group on Computer Technology. During the eleventh session of the Advisory Committee, this *Ad Hoc* Working Group met and made some preliminary comments and observations. In order to supplement the materials, information and suggestions that were presented from all these sources, the Secretary-General commissioned a number of specialists to prepare background papers.

4. From 24 to 27 February 1970, an *Ad Hoc* Panel of Experts was convened by the Secretary-General. The list of members of the Panel and participants is contained in annex III. The report of the Panel

of Experts was widely circulated for review and comments to organizations in the United Nations family, to professional computer organizations and to other interested bodies and individual specialists.

5. The Advisory Committee on the Application of Science and Technology to Development accepted the invitation of the Government of Romania to hold the meeting of its *Ad Hoc* Working Group on Computer Technology in Bucharest on 13 and 14 April 1970 and authorized the Working Group to communicate its views and comments to the Secretary-General on behalf of the full Committee. At that meeting, the ACAST Working Group formulated its views on the draft report which had been prepared by the Panel of Experts. It was also informed of and took into account the comments and observations received on the report of the Panel. The report adopted by the ACAST Working Group is contained in annex II.

6. The present report comprises two main parts. Part One discusses programmes for developing countries while Part Two deals with caveats, barriers and incentives with respect to computer technology for development.

7. In operative paragraph 1 (*a*) of resolution 2458 (XXIII), the Secretary-General was asked to present the results already obtained with respect to the use of electronic computers in accelerating the process of economic and social development. Unfortunately, the responses received from Governments contained insufficient data to provide a clear description or assessment of computer installations or usage in the developing countries. Some useful data were obtained and have been used extensively in the preparation of the present report. The other aspects of the situation specified in the resolution have been dealt with fully in the report. This report should be regarded as a first endeavour to take a general view of the application of computer technology for the benefit of the developing countries; as such, it has been able to point out some of the main elements involved and formulate a number of principal conclusions and recommendations.

8. During the Second United Nations Development Decade, the developing countries will need to call more fully on relevant technology to accelerate their development; computer technology is one important element in determining the rate of technological change. The continuing growth of computer technology and its application in the industrialized countries will be a general feature of the 1970s. Increasingly, it is being recognized that in itself the computer is not a panacea and that all the difficulties and consequences of using computer technology need to be considered. A long-term commitment will be required by the individual Governments of developing countries, which may in turn contribute to lessening the gap between the developed and the developing countries in the application of computer technology. It is expected that the Second United Nations Development Decade will be a period during which the developing countries will be able more fully to utilize computer technology, under sound and realistic conditions, to improve the rate of their desired economic and social change.

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Brief description of computers

9. A computer is a device to process information; it has a means of accepting information (input), a means of storing information (memory), a means of processing the information (central processing unit), and an output device. The processor performs arithmetical or logical operations on the data, and the memory stores both input data and intermediate results. The computer memory also stores the information which specifies the sequence of operations to be performed (the stored program[1] or machine language program).

HARDWARE

10. The physical parts of a computing system are collectively called computer hardware.

11. The major components of a computer system are:

(*a*) Input equipment: card readers, punched tape readers, keyboards, document readers;

(*b*) Central processor: the unit which carries out the logical and arithmetical operations;

(*c*) Memory: devices for storing both data and instructions on how to process the data; magnetic cores, magnetic disks or magnetic tapes are examples;

(*d*) Output equipment: line printers, plotters or display devices.

12. Card readers are most widely used for input, but document readers are coming in to use as their reliability increases. A number of companies are developing equipment which enables data to go directly from keyboard to magnetic tape.

13. Central processors vary in capability and in speed; the larger processors are the most economical.

14. Most high speed memories are made with magnetic cores; a few computers have extra high speed "scratch-pad" memories made of thin-film magnetic materials. Intermediate speed memories use magnetic disks or drums, and magnetic tapes serve as slower speed memories. Access time, the time it takes to transfer an item or group of items from its location in storage to where it is needed, ranges from microseconds (millionths of a second) to hundredths of seconds for disk and drums and to minutes for random access to information on magnetic tape. The price for storing an alphabetic character varies with speed, from $0.25 for core storage to perhaps $0.0001 for storage on magnetic tape.

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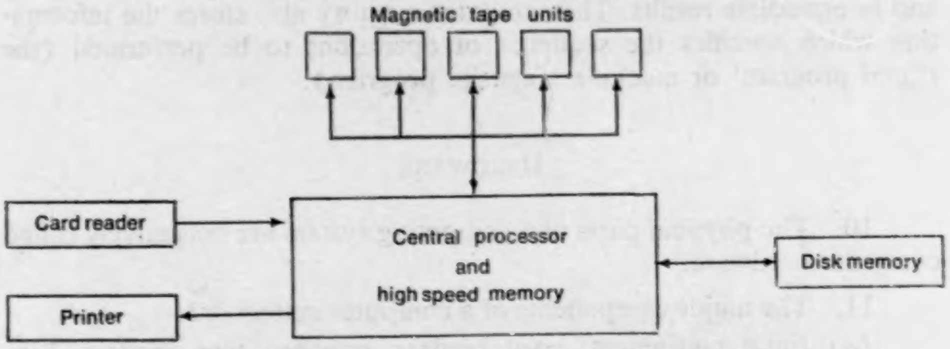
[1] "Program" and "programme" are two alternative spellings for the concept of "a plan to be followed". In this report the spelling "program" indicates a set of instructions and data specifying a computational or data processing plan. For other plans, the spelling "programme" is used—for example, an educational programme.

15. A typical line printer prints a line 132 characters long and at rates of 1,100 lines per minute. Manufacturers are beginning to offer display devices that show text and can do curve plotting.

16. Figure I shows the organization of a typical computer system.

Figure I. Organization of a computer system



17. Systems for administrative and business applications must be capable of handling large files and large volumes of input and output in which the data may be numerical or alphabetical. The terms automatic data processing (ADP) and electronic data processing (EDP) are used to describe such operations. A more complete discussion of computer hardware is given in annex I.

SOFTWARE

18. Before a computer may be used a program must be established in its memory. The program is a set of instructions specifying a sequence of arithmetical and logical operations to be applied to a given set of data (a plan to be followed). When the instructions refer directly to the hardware components of the computer they are converted simply into electrical signals which activate the physical devices. Such a list of instructions and associated data is referred to as a machine language program. Machine language programming is tedious and may give rise to error. Therefore, with the first commercial deliveries (see annex I, para. 5), a symbolic assembly language was developed and a translating program was written: this was a computer program which when executed caused the computer to accept statements in the assembly language and generated machine language commands. This permitted the user to refer to quantities by symbolic names. Along with assembly languages came the technique of developing programs in sections (called subroutines) in such a way that they could be used with other programs, and libraries of subroutines could be collected and distributed.

19. The operating system was a highly significant software development. This is a resident program which allows the computer to accept and process one job after another without requiring operator

action between jobs. There is no waste of time between jobs, an especially important factor when there are many small jobs each requiring only a few seconds to run. Even in large installations working on large problems, numerous short runs are required to "debug" subroutines, that is, to check them for errors. When the pieces are correct, the whole program is assembled and tested on small sets of data. A good operating system can double the throughput (number of jobs run per hour) of a computer system.

20. Systems were developed that would accept a job stream, line up the jobs and select them to be run according to priority. Short "debugging" runs to find errors can then be put ahead of long production problems.

21. High performance systems have several input devices and printers, permitting several job streams at a time. Multiple input/output channels can be established at remote locations to make a remote job entry system.

COMPUTER LANGUAGES

22. Symbolic assembly languages were followed by problem-oriented or procedure-oriented languages. The first of these was Fortran (formula translator) which accepted statements of a mathematical type. This was followed by Algol (algorithmic language) and by Cobol (common business oriented language).

23. The standardization aspects of these languages are of interest. Fortran and PL/1, another computer language, were *de facto* standards established by one computer manufacturer; Algol resulted from professional society co-operative efforts; Cobol was sponsored by the Government of the United States of America.

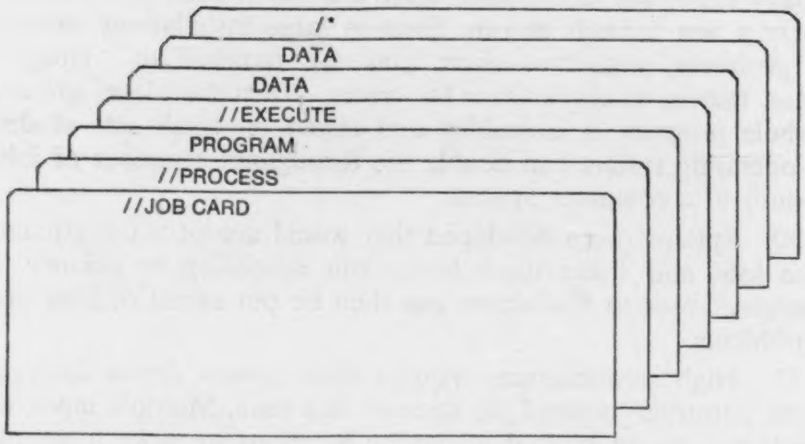
24. In another class, there are special purpose languages. SIMSCRIPT, SIMULA and GPSS are designed for specifying machine tool control. IPL-V, LISP, and SNOBOL are string processing languages for symbol manipulation.

25. Since computer hardware is costly, the first operating systems were designed to keep the hardware busy even at the price of making users wait. A more recent mode of computer operation is time-sharing, an arrangement where one computer serves many users, each at his own terminal. The computer serves each user in turn in such a way as to keep him occupied between turns. Reliable performance of time-sharing systems depends, among other things, upon the quality of the communication lines between the terminals and the computer. Additional descriptions of computers and their uses are given in annex I.

A COMPUTER JOB

26. The functions of software can be illustrated by examining how a computer processes a job submitted to it in the batch mode. For purposes of discussion it will be assumed that the problem is to be read into the computer from cards. For a typical operating system the deck might have the following structure:

Figure II. Structure of a job deck



//JOB CARD	identifies the user.
//PROCESS	specifies the process involved. For example, it may specify that the following cards are in Fortran and that the Fortran translator should be applied to them.
PROGRAM	contains the program. The number of such cards may vary.
//EXECUTE	indicates, for example, that the program should be run after translation.
DATA	contains input data, if needed. The number of such cards may vary.
/*	denotes end of program.

27. The operating system looks for the job card. If the user is on the approved list it continues; otherwise the cards are passed through the reader with no processing and an appropriate message is printed. If the next card says "execute Fortran" the Fortran translator is loaded into the core memory and begins to process the cards of the program. If an error is found, the translation terminates and the rest of the cards are passed through the reader. According to the quality of the Fortran translator, a more or less lucid error message appears on the printer.

28. If the translation is successful the operating system looks at the next control card. If the instruction is "execute", the user's program, the result of the translation from Fortran, is loaded into the core memory and execution starts. If the program calls for data, data cards are read in and the execution of the program continues. Either the program terminates as planned when the end of program card is read, or some unplanned event occurs.

PRINCIPAL CONCLUSIONS AND RECOMMENDATIONS

29. From the information provided in response to the Secretary-General's questionnaire and from the analysis in this report, a number of principal conclusions and recommendations may be drawn. These will require appropriate action by Governments in both the developed and developing countries, by the United Nations and organizations in the United Nations family, by national and international organizations and institutes, by industry both public and private and by national and international professional and user organizations in the field of computer science and technology and in related areas.

Conclusion I:

Education and training for the application of computers to accelerate the process of economic and social development must receive first priority.

Therefore, it is recommended that, in the developing countries:

Recommendation 1—Appropriate centres at the national and regional levels be established or strengthened;

Recommendation 2—Education and training be supported at all levels, ranging through operators, programmers, computer scientists, computer systems analysts, managers and policy-makers as well as the general public;

Recommendation 3—Means be found for creating materials and developing techniques for teaching the effective use of computers and these efforts be encouraged;

Recommendation 4—Better means for exchange of technical information be established.

Conclusion II:

Each developing country needs a broad national policy, consistent with its national goals, on the application of computer technology.

Therefore, it is recommended that each developing country:

Recommendation 5—Formulate a plan containing realistic goals, listed in order of priority, so that orderly short-term and long-term development may take place;

Recommendation 6—Allocate sufficient resources to implement such a plan.

Conclusion III:

International co-operation needs to be increased in activities relating to the application of computer technology to development.

Therefore:

Recommendation 7—The Secretary-General believes that the General Assembly may wish to consider the proposal made by the *Ad Hoc* Panel of Experts and supported by the ACAST Working Group for the establishment of an international advisory board on the application of computer technology for development which could report annually to the Secretary-General who would transmit the report to the Economic and Social Council and the General Assembly. Two broad types of function might be envisaged for such a board:

(*a*) To promote the application of computer technology for development through international co-operative efforts in association with the United Nations family of organizations;

(*b*) To provide, upon request, independent and objective advice to assist developing countries in their decisions on the use of computer technology for their development;

It is also recommended that:

Recommendation 8—Governments of developing countries be encouraged to request the assistance of appropriate organizations in the United Nations family in connexion with efforts related to Recommendations 1-5;

Recommendation 9—Organizations and institutions in developed countries be encouraged to establish "twinning" relationships with organizations in the developing countries and that United Nations programmes support such action;

Recommendation 10—The United Nations family of organizations call more fully on the international professional organizations in their technical assistance and information dissemination activities;

Recommendation 11—Efforts by user groups, manufacturers and the professional community to enhance the compatibility of both hardware and software be encouraged.

Conclusion IV:

Computer technology will increase in importance in the developing countries during the Second United Nations Development Decade and its diffusion and sound application can make a significant contribution in accelerating the rate of their economic and social development.

30. Therefore, it is important that in the developing countries:

(*a*) The analysis and systematization that occur when computerization takes place be recognized in itself as a most significant contribution to improving management decision-making and resource allocation;

(*b*) Attention be given to the need to improve the quality of collected data;

(*c*) The commonality of computer techniques in many disciplines be recognized;

(*d*) The benefits of purchase *versus* rental of computer equipment be carefully studied (In some developing countries, a national leasing company may be appropriate, while in other parts of the world a regional approach to the lease/purchase problem may be desirable.);

(*e*) Trade barriers including customs regulations impeding the international movement of equipment, magnetic tapes and cards be minimized;

(*f*) Exchange of software and data under appropriate conditions of protection be facilitated and encouraged.

Part One

PROGRAMMES FOR DEVELOPING COUNTRIES

I. COMPUTERS IN DEVELOPING COUNTRIES

31. Technology has an essential role to play in reducing the disparities that exist between the developing and the developed countries. Computers are especially important in this context, because so many computer applications have a direct bearing on some of the main facets of the development process and reflect certain aspects of the technology that has facilitated the growth of the economically advanced countries.

Development and transfer of technology

32. Technology is the knowledge of the industrial arts; a technological change is any change which affects a product or the process of producing it. In February 1963, as a result of the Economic and Social Council's recognition of the crucial role of science and technology in development, the United Nations convened a major conference on the application of science and technology for the benefit of less developed areas.[2] Many of the arguments and conclusions of that conference are relevant to this report. Certain general topics discussed there, such as education and training, methods of achieving international co-operation, organization and planning for development, and specific points such as the desirability of installing older equipment in the less developed countries are important in the context of computer technology. It is not surprising that the precepts which hold for the transfer of technology in general also hold for computer technology in particular; this theme will recur many times in the present report. Since 1963, individual economists and organizations for studying the economies of countries have continued to focus attention on technology, technological change and technological forecasting.[3] Technology is not the only key to reducing the disparities between the developing and the developed countries,[4] but technological progress is essential.

Computers and technology

33. Although in many respects the transfer of computer technology is like the transfer of any other technology, computers have a

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[2] *Science and Technology for Development* (United Nations publication, Sales No.: 63.I.21-28). A summary of this conference was presented in the Report of the Secretary-General to the United Nations Economic and Social Council at its twenty-sixth session.

[3] See E. Mansfield, *Economics of Technical Change* (New York, W. W. Norton, 1968); Organisation for Economic Co-operation and Development, *Gaps in Technology: Electronic Computers* (Paris, OECD publications 1969) and E. Jantsch, *Technological Forecasting* (Paris, OECD publications, 1967).

[4] International Bank for Reconstruction and Development, *Partners in Development: Report of the Commission on International Development* (New York, Praeger, 1969)—emphasizes the urgent measures which will also have to be taken with regard to aid, education, research, trade and population control.

special position. They are the result of one of the most remarkable growths the world has ever witnessed. It is just two decades since the very first electronic computers began to operate, and yet in this short span there have been three full generations of machine evolution. Computers were first used for science and research, and then were rapidly adapted to business and government administration. Today they are used everywhere; in the physical, social and life sciences, in engineering and manufacturing and in the private and public sectors.

34. Perhaps the most important aspect of computers is that in the course of introducing them to carry out a task, people are brought to reassess the whole way in which the task should be done. In fact, computers often lead to a re-evaluation of why the task is being done. This examination of ends and means is fully as important as the introduction of the computer itself. The world has come to recognize that computers can in themselves be one of the principal instruments for the transfer of technology.

35. Significant as the penetration of computers into industry and technology has already been in North America and in Europe, there is no sign of slowdown in the installation of new equipment or in the widening of the range of applications. But in developing countries, as with all too many aspects of technology, computer use is still slight.

36. Even where computers have been introduced there is often underutilization of the equipment because, for example, there are not enough people with training and experience to apply the new methods. Concerted action for the transfer of computer technology to developing countries is of top priority.

Current installations of computers in developing countries

37. One of the purposes of the questionnaire circulated by the Secretary-General to Governments of Member States was to obtain an idea of the number of computers in developing countries, and their use. Altogether fifty-one countries replied to the questionnaire (see annex V): ten in the Americas, seventeen in Europe, twelve in Africa and twelve in Asia and the Far East. As noted by the ACAST Working Group (annex II, para. 18 (*c*)), this large number of replies demonstrates the importance that Member States attach to computer technology. However, the data provided in the questionnaire replies were not adequate nor were the answers sufficiently detailed to give a representative or clear description of the extent to which computers are installed or being used in developing countries. Although some conclusions may be drawn from the available data, much more information on computer installations and applications in the developing countries will be needed if a detailed and meaningful picture of the results and needs for the use of electronic computers in accelerating the process of economic and social development is to be achieved. The ACAST Working Group (annex II, para. 18 (*b*)) supported this view as well as noting the need for more information. Detailed and periodic surveys of the

computer industry and technology in the industrially advanced countries are available, but the results of these are not applicable to the developing countries.

38. Of the Governments that responded to the Secretary-General's questionnaire, three indicated that they had no computers, five that there was one computer in their country and eight that there was more than one computer, while the others did not provide aggregate numbers. Occasionally the distribution of computers between the public and the private sector was given: table 1 lists these figures. By way of comparison with the developed countries, in 1969 Canada had 259 computers in the public sector and 1,669 in the private sector; Japan had 154 and 5,447, respectively.

TABLE 1. SOME EXAMPLES OF DISTRIBUTION OF COMPUTERS IN THE PUBLIC AND PRIVATE SECTORS IN DEVELOPING COUNTRIES, 1969

Country	*Public sector*	*Private sector*	*Total*
India	69	42	111
Chile	18	15	33
Nigeria	7	3	10
Trinidad and Tobago	7	7	14
Iraq	1	5	6
Thailand	6	7	13
Republic of Korea	10	4	14

SOURCE: Information based on replies of Governments of Member States to the Secretary-General's questionnaire.

Applications of computers in developing countries

39. The broad range of computer applications which are important to social and economic development are outlined in annex I, paragraphs 26 to 70. Briefly, these cover the following major activities, within which many subordinate activities can be identified: (*a*) government planning and administration; (*b*) collection of statistics on production and resources; (*c*) management of national industries; (*d*) public health administration; (*e*) preparation of economic indices; (*f*) education and research; (*g*) demographic tabulation, analysis, projection.

40. It is apparent that all these are potentially of interest to developing countries. According to the incomplete information given in the replies of Governments of Member States to the Secretary-General's questionnaire, the applications most commonly found in developing countries are to demography, censuses, and government administration and accounting. Fifty-four different areas of application, not all distinct,

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were mentioned by sixteen of the countries. The following areas were mentioned with the indicated frequencies:

Statistical computations	10
Transportation	8
Research computations	7
Accounting	6
Financial computations	6

41. These applications are similar to those first made when computers were introduced into the public sector in the industrially advanced countries. Usually they are automatic data processing (ADP) versions of government tasks which are of major importance. Sometimes the conversion to ADP is undertaken early because it is justifiable and may be readily implemented, for example, where there are good programs available from the manufacturer, people with considerable experience in the application or data in a form easily made machine-readable. Although the simplest applications are not necessarily the best ones to convert to ADP first, they do provide an opportunity for a country to obtain experience.

42. With regard to the ways in which computers are actually used in developing countries, it is possible to point to cases where the approach is as sophisticated and the results as striking as any that can be found in an industrialized country. In general, however, determining where computers can be used to maximum effect in developing countries is a matter of great difficulty and great importance. It depends in part on which sector of the economy it is desirable to emphasize, on national priorities and on the political, social and economic implications of the results. It also depends on certain preconditions, the most important of which is the presence of experienced people. An analysis of the replies to the Secretary-General's questionnaire reveals that the clearest need in the developing countries is for training and education in the field of computers, so that applications important to development can be undertaken. This need is exposed in almost every one of the replies received from the developing countries. In section II of the present report the types of training and education which are needed are considered in detail. After education and training, the need for better access to computing facilities was emphasized. The types of facilities and services which are required in the developing countries are examined in section III.

43. Additional needs include the existence of good data bases and information systems as outlined in annex I, paragraphs 30 to 37. These systems do not necessarily have to be computer-based, but they must be reliable. Simultaneously, it is necessary to develop related disciplines where computers are used—in management science, statistics and operational research for example. These prerequisites and priorities are discussed in greater detail in section VII.

II. EDUCATION AND TRAINING FOR COMPUTER TECHNOLOGY

44. The scale of development described in the previous section demands education and training at various levels, ranging through that of the policy-maker, the manager of the computer centre and the specialist. Above all there must be people at the highest level of government who understand the possibilities and limitations of computers for development and can make decisions concerning them.[5]

Education of decision-makers, managers and computer systems analysts

45. Those who make decisions about the allocation of resources in developing countries are usually sensitive to the political, economic and cultural forces at work within their country and knowledgeable about a whole range of management techniques. It is essential to make those responsible for planning and decision-making aware of the sound, economic possibilities of the computer. Decision-makers are usually overworked; they must nevertheless be encouraged to learn what can be done with a computing system by attending orientation seminars, visiting computer centres, and generally keeping abreast of developments in this field. Otherwise they will be subject to the pressures of local computer salesmen who paint optimistic pictures of what computers can do and fail to tell of the pitfalls and deficiencies. Consequently the costs for setting up a computer operation often turn out to be substantially greater than anticipated and more time is needed for the installation to become productive. Another source of information for the decision-maker is a counterpart in a neighbouring country with whom to compare decisions. This is not always successful as mistakes as well as successful moves may be imitated. In the parts of the world where seminars and courses designed for decision-makers are not available, the United Nations family of organizations or its agencies have an important task in filling this need.

46. Management training programmes include courses on economics, labour-management relations, operations research and systems analysis. Computer systems analysts are concerned with the structure and mechanism of organizations. A basic method in computer systems analysis is to identify the type and nature of information needed by an organization, the origin and recipient of the information, the responsibilities of, and action to be taken by, the recipient of the information and the channels to be used in the flow of information.

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[5] See also the comment of the ACAST Working Group in annex II, paragraph 18 (*a*) and (*b*).

47. Since computers are so important in modern information systems, training programmes for both managers and systems analysts should include the opportunity of actually working for a time in a computer centre, as well as attending basic courses on such subjects as flow charting, data preparation, file management and report generation. Of particular interest is the increasing use of computer-based management games where students are introduced to a computer simulation which requires them to compete against others in making decisions and allocating resources. These subjects are being incorporated into the curricula of the management and business data processing courses offered in the industrially advanced countries and the need for them has been clearly recognized in courses offered by the United Nations family of organizations in the developing countries (see section IV). One problem is that unless managers have attended these courses before their computers are installed, the latter will probably be underutilized for a time; on the other hand, the presence of computers is necessary for the courses to be effective.

Training of automatic data processing (ADP) managers and supervisors

48. An ADP manager must understand his computing system and deal with employees, users and vendors of equipment. The only adequate training for the job is years of experience in a computing centre.

49. An experienced manager for a computer centre is hard to find, especially for a developing country acquiring its first computer. The most competent person available should be selected and sent to an appropriate centre to complete his training even before the decision to install a computer is made. Since in practice this seldom happens, the country is often obliged to seek managerial help through a technical assistance programme.

Training of systems programmers and applications programmers

50. Computing systems depend on software related to operating systems, user languages and translators, library programmes and programmes for special tasks. The system programmer must understand how these components fit together: how to use languages and subsystems, correct errors which may be present in a system which has been long in use, install new software capabilities provided by the manufacturer and be able to tell users how to bring their programmes up to date. He must also advise the director of the computer installation about the purchase of equipment and software. Few formal courses for training systems programmers have been developed and so far there has been no alternative to having a trainee spend at least a year in a well run computer centre working with experienced people. If possible he should first have spent one or two years as an applications programmer, and should continue his training through participation in

user group meetings and perhaps even courses sponsored by the manufacturer. Because of the long lead time required to train systems programmers, most installations begin functioning with people who are not adequately trained.

51. Though there are straightforward and well understood procedures for training computer specialists in most categories, computer applications range over so many subjects that no one individual can be expected to be a general applications programmer. A data analyst needs to know which statistical methods are valid. A physical scientist may wish to solve very complex mathematical problems involving differential equations or integral equations and will need to know which algorithms or procedures will yield reliable answers. In other areas of application, such as payroll, the mathematical processes may be simple, but the complexity of choices may be such that it is almost impossible to define the procedures sufficiently clearly to run them on a computer. The applications programmer may be requested to design file systems. He frequently finds himself doing the whole system design. According to the area in which he is working he will find different programming languages such as Fortran, Cobol, Algol or report generating languages, more suitable than others.

52. An applications programmer needs to be highly trained in his own field; instead of a professional programmer being trained to become an applications programmer, it is preferable for the professional in some particular discipline to be given training in programming and so become the applications programmer for that area. The limitations of this method of training should be recognized. Until the person involved becomes proficient in programming, he should be encouraged to review the systems he designs with those who have had extensive experience. This is especially important when creating systems with large data bases, since these are difficult to change once they come into existence. A programming expert, even without detailed knowledge in the field of application, may suggest data structures and programming techniques which can simplify processing and significantly reduce costs.

Training of engineers, technicians and operators

53. Maintenance engineers and technicians need different training from that of computer operators, programmers and users. Their background should be in electrical engineering, mechanical engineering, logical design and communications, and the usual practice is to start with graduates from engineering or technical schools in these areas and supplement their training with courses on computer hardware. When the computer is rented, the prime responsibility for maintenance lies with the manufacturer. When it is purchased there is usually an option to have maintenance supplied by the manufacturer.

54. The choice of continuing contract maintenance or undertaking it locally depends on many factors and there is no obviously best decision for all countries. The arguments for taking over maintenance

are: (*a*) the foreign exchange advantage; (*b*) the forced development of an electronic engineering capability; (*c*) the establishment of a solid base for future development in computer technology. Romania, for example, has chosen this course. They have established a national organization to carry out this function for all computers in the country.

55. The disadvantages of undertaking maintenance locally are: (*a*) the cost of maintaining an adequate supply of spare parts; (*b*) the need for import licences to obtain parts and the foreign exchange problems involved; (*c*) the problems of training maintenance staff; (*d*) the difficulties of acquiring information about current diagnostic procedures used by the vendor; (*e*) access to information about expected failures and failure characteristics of the equipment.

56. Those working with computers for process control and other production techniques will also require an engineering or technical background, preferably in the field of engineering in which the computer is being used—chemical, power or mechanical engineering, for example. Here also training programmes should be arranged with the manufacturers, supplemented by training at installations where equipment is being used for similar purposes.

57. Trainees learning to operate computers do not need an extensive education; they need practical experience in working with computers. In addition to operators, people are needed for data handling and supervision, and for handling files in both machine-readable and conventional forms. A country must have an installed computer to train such workers locally. However, if there are computer facilities in the region it should be possible to send people to them for on-the-job training. The alternative is to depend upon the manufacturer who offers training programmes using his hardware. Eventually such training will probably be given in technical schools. Frequently computer activity in a developing country starts with a commercial installation. Although there are difficulties—private companies are sometimes reluctant to have outsiders using their computers—a developing country should explore the possibilities of training on such computers. Consideration might also be given by private companies in the developing countries, wherever circumstances are appropriate, to the idea of offering their facilities for these purposes.

Curricula and professional evaluation

58. Even in the industrially advanced countries most universities have not provided the professional training for the tasks outlined above. University programmes in computer science concentrate on the mathematical and theorical aspects of computers required for research, including numerical analysis, automata theory, the theory of formal languages and logical design. Courses on programming languages and operating systems are useful to systems and applications programmers. Training for the skills mentioned earlier has usually been given on the job, in schools operated by the manufacturers, in courses sponsored

by the professional societies and, to an increasing degree, in junior colleges and schools. Those universities in developing countries that are building up educational programmes in computing should realize that courses in management science, data processing and systems programming are highly relevant to the needs of the country.

59. One result of teaching these more applied subjects outside the traditional academic disciplines is that formal curricula, teaching materials and well recognized methods of professional evaluation have been slow to evolve. Efforts towards this are now taking place and the United Nations family of organizations can make a valuable contribution to them. Developing countries and their universities need encouragement and support for their recognition of the new technical and professional categories which are being established. In this way young people in the developing countries would be drawn to enter careers in these important fields.

Education and training abroad

60. For many years developing countries have been sending their best students and professional people in the field of computer technology abroad for specialized education and training. Some go to universities, some to governmental agencies and some obtain experience in the private sector. Problems can arise with regard to training abroad. The typical student who is away for one or two years may lose touch with the conditions in his home country and may have difficulty working with or acquiring the confidence of his fellow nationals upon return. There may be a lack of trust if he has been in a foreign political environment, or simply an estrangement due to the existence of different viewpoints. Although it is difficult to plan far enough ahead, it is helpful if the country has well formulated plans and programmes for these students when they return home. In all cases follow-up work should be done with regard to the person who has received training abroad, to evaluate the programme in which he participated and derive the maximum benefit from his experience.

61. An additional difficulty connected with education abroad is the "brain drain", with the attendant loss to a country if the student elects not to return because of opportunities offered him in the foreign country. It has been reported recently[6] that in the United States for every three engineers who have graduated from United States schools a fourth is provided by immigration. Of those from abroad, one in ten comes from India, one in four from other countries of the Far East and forty per cent from western Europe.

62. Where there are national or regional centres to provide training and practical experience, the student is never far from his home environment and many of the problems described above are not present or may be minimized.

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[6] See *Engineer* (March-April 1970), p. 10. See also report of the United States National Science Foundation entitled *American Science Manpower, 1968* (Washington, D.C., December 1969), document No. NSF 69-38.

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63. Although there may be regions where it is necessary to create new centres, most countries have existing institutions—universities, technical schools and government-supported facilities—which could undertake either national or regional programmes. In some cases it will be necessary to install or upgrade the computing facilities, but it will usually be preferable to build on an existing structure than to create a new one which may be isolated from the other teaching and operational activities to which it should relate. For this reason it is proposed that the technical assistance programmes described in the next two sections be concentrated, in the main, in existing national and regional institutions.

Educational consultants

64. Another approach to education in the field of computers has been to invite outstanding professional people to set up and participate in educational programmes in the developing nations. An example is the development of the Indian Institute of Technology at Kanpur in India, where from twenty to twenty-five American visitors (each serving terms of from one to two years) constantly augmented the faculty during the first decade of its development. This kind of programme is not without its problems. Professional persons find it difficult to be away from their work for more than one year, and one year is hardly enough to establish a continuing programme. Nevertheless, many university faculty members have participated, because this type of programme can be co-ordinated with sabbatical leave. In some cases, visits of short periods have been successful but all too often the activity dies out and the value of the visit is lost. It has been suggested that the first visit should last at least a year and be followed by several short visits to sustain activities.

65. In order to obtain consultants in fields such as data processing, where people are not usually available from a university under a sabbatical leave arrangement, it may be necessary to employ professional consulting firms. When an expert goes to a developing country as an individual, he may be at a disadvantage with regard to his professional career on his return. But when a professional consultant goes, he is carrying out an assigned task and on return will go on to a new assignment. In this connexion it might be suggested that organizations of the United Nations family should use more professional consultants, particularly for subjects outside the normal interests of the academic community. In proposing this it is necessary to caution against consultants who offer standard solutions applicable in highly industrialized countries but not in developing countries. Short-term visits by experts must therefore be planned carefully with experts in residence and with nationals in the developing countries, so as to draw upon all the useful sources of experience, in both the developed and developing countries. Attention should be called to orientation courses such as those sponsored by the Ford Foundation in India.

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These are of substantial help in introducing the visiting expert to his new environment.

Special teaching materials

66. There is a chronic shortage of competent teachers of computing in developing countries. A great effort must be made to provide special teaching facilities and materials to augment the capacity of the teachers and to achieve better distribution of those high quality materials related to the teaching of computing which already exist. Any new teaching materials and techniques must be examined closely as to their educational effectiveness in relation to costs, and alternatives that may be available or could be developed must be considered. Prerequisites of these new materials and techniques, such as opportunities for training teachers in their use, must be present, and the limited experience with these materials under certain conditions in the developing countries should be considered.

67. Among the techniques which have been used successfully are:

"Packaged" teaching materials, such as film strips, slides, video-tapes, films, "programmed-learning" textbooks (possibly accompanied by tape cassettes) and programme packages to be used on time-sharing systems; all the potentialities of audio-visual presentation, preferably with the additional features of "programmed learning" and conversational learning can be exploited. The creation of teaching materials of this sort requires a great deal of manpower, especially in the production and improvement of the contents. However, if the material is used by very many students, there will be an over-all saving.

Television broadcasting: a series of televised lectures on computer programming is a promising means of mass education. Such a series may be incorporated into the curriculum of a programme like "University of the air", wherever these institutions are organized. Here again, tutorials and follow-up work in the form of exercises are desirable.

68. It is important to supplement all the specialized techniques described here with opportunities for personal assistance, and for the submission of practical exercises on computers, as well as with follow-up action. In many cases the follow-up work may be difficult. Even universities equipped with an adequate computer may have difficulty in handling the exercises submitted by a very large number of students. One solution is to use mark-sensed cards or optical character recognition (OCR). By the former method, students mark cards with special pencils and the marks are later read mechanically; by the latter, the markings are read by an optical reader. Processing systems based on these types of input are possible in both a university environment and with programmes offered to the public at large. However, optical character recognition equipment has been developed more recently and is less reliable than other computing equipment. Decisions as to its use require careful control of the quality of input documents.

69. UNESCO should be encouraged to maintain current information about teaching materials and to see that the information is dis-

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seminated widely in the professional literature. Although teaching materials have their place there is no substitute for the actual solution of realistic problems on computer.

Specialized training and education

70. In view of the competitive aspects of computer hardware and system development by manufacturers, developing countries will find it particularly difficult to initiate specialized training and education and to build up a group of people with competence in these subjects.

71. For those developing countries in the more advanced levels of computer activity it may be feasible to design and build devices using imported integrated circuits and to develop software systems. In these areas there is substantial technical competence in the universities of the industrially advanced countries and there already exists a policy which facilitates the flow of information. For example, many universities have been designing peripheral devices for their computers and most of the existing time-sharing systems were designed in universities.

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III. COMPUTER FACILITIES AND SERVICES

72. This section examines the type of computing facilities which should be available to developing countries, beginning with a discussion of national and regional facilities. Later the equipment needs and services of a national (or regional) computer facility are detailed. Particular configurations or suppliers are not specified, for the choice of these will depend on the companies operating in the area and on the types of equipment available.

National and regional computer facilities

73. The recognition, implicit in General Assembly resolution 2458 (XXIII), that developing countries need computing facilities for social and economic development, and educational and training programmes to use the facilities, was confirmed by many Governments in their responses to the Secretary-General's questionnaire. It is impracticable to entertain the idea of a single, large computing facility sponsored by the United Nations for all the needs of the developing countries. On the other hand, a minimum national computing system represents a substantial investment in hardware, facilities and staff. Although it is a significant step to make the initial installations (see paras. 37-38), many of the developing countries have installed one or even several computers for governmental functions. But small developing nations may not be able to allocate the necessary resources unless assistance is given them in an appropriate way.

74. This leads to a consideration of regional centres and activities.[7] The extent to which United Nations programmes should be based on a regional approach has been much debated. There is always the danger that a regional activity will not function because of primarily political forces dividing the countries of the region. Even when these are not present it may be difficult to establish a region. With respect to computing for example, developing countries with well established computing centres may feel that they will gain from a regional activity. They may wish to educate and train their staff at advanced educational institutions in the developed countries. The choice of whether to participate in a regional activity will have to be determined by each country for itself. For many countries there will be incentives. Even if they are willing to commit financial resources for national facilities, they are unlikely to find the professional staff necessary to operate the facilities effectively. For Africa alone it has been estimated that at least thirty national computing facilities are required. To suggest that the establish-

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[7] This question of regional and national activities was discussed extensively by the ACAST Working Group, see annex II, paragraphs 7 to 9.

ment of all these centres in the immediate future should be an initial goal would be unrealistic from the viewpoint of both finance and personnel. Regional computing centres or regional programmes sponsored by the United Nations employing the facilities of national centres can be used as a transitory stage for initial training by countries without computers. Furthermore a regional activity could provide a means of upgrading the level of competence of a national computer activity. Since the technology at a regional centre can be at a higher level of sophistication, it will be easier to attract international experts as visitors and resident staff. There are operational examples of activities on a regional basis in such fields as meteorology and international air traffic. In West Africa, the Airways Corporation, the Examinations Council and the Medical Research Council are cases of effective co-operation. Regional computing activities should be encouraged and supported wherever a group of Governments indicate their wish for co-operation on this basis.

75. If regional centres are decided on, there is the question of how they should be managed and operated. It is proposed in section VI that they be associated with the regional economic commission. A close relationship could strengthen both, for their functions can be complementary.

76. A regional centre may have its own staff and equipment or it may have its own staff and use equipment belonging to other international or to national activities: or again, even the services of staff could be arranged on a contract basis. Generally, it is proposed that the teaching programmes be carried on by visiting staff. In this way the regional centre can vary what it offers to meet the growing demands of the region.

77. With regard to facilities, there is the possibility that one manufacturer or company might be invited to install a facility which would be operated on a service bureau basis. Finally there is the possibility that some agency, such as a consultant group or a university would be invited to install and manage a facility under contract for a number of years.

National advisory bureaux on computing

78. The requirements for computing in government administration are so numerous and varied, and arise in so many functional areas that most developed countries have found it necessary to set up advisory committees, agencies or bureaux for computing. The responsibilities of these groups vary widely, depending on whether the agency is expected to formulate policies and guiding principles for the acquisition of new facilities, serve as an advisory board for co-ordinating facilities and ensuring compatibility, actually carry out service bureau operations for governmental departments or act as a training bureau. Advisory and policy committees exist in Australia, Belgium, Canada, Finland, France, Israel, Norway, Sweden, Switzerland, the Netherlands, the United Kingdom, the United States, the Federal Republic of Germany

and in many other countries. These committees are usually responsible to the treasury or financial department of their respective Governments or exist within an office of organization and management. In many cases they have been set up only within the last two or three years. In some countries there are separate advisory bureaux for the different levels of government. In the Netherlands, for example, there are three automatic data processing committees, one for each of the three levels of government—central, provincial and municipal—and in Israel there is also a special committee for advising municipalities on computer applications.

79. Developing countries often need a source of advice on broad policies related to computers, and to the establishment and management of national computing centres and government bureaux. Regional activities supported by the United Nations through technical assistance programmes are one source of such aid (see paras. 107-108). The professional societies have indicated their willingness to help developing countries (see paras. 142-147) and the Intergovernmental Council for Administrative Data Processing (ICA), an informal body of representatives from centralized government computing installations, is prepared to help (see annex IX).

National computing bureaux

80. Annex I, paragraphs 38 to 42, describes how in the developing countries, as well as those which are industrially more advanced, the basic tasks of government are increasingly being carried out with the help of computers. A frequent approach is to set up a centralized government computing bureau to carry out these computing tasks for a number of government departments. Such bureaux have been set up in many countries, including Australia, Canada, Denmark, Finland, Israel and Switzerland. These bureaux may provide services only for Governments, or they may, as in the case of Chile, undertake work for the private sector as well.

81. As computers take over more tasks in a country, the need for greater computing capacity arises and the problem arises of whether to provide this by acquiring additional computers or by enlarging the capacity of existing installations. This problem is a variant of one which Governments recurrently face: whether to centralize or decentralize their facilities.

82. In favour of centralized government service bureaux there are the following arguments:

(*a*) Costs are lower for a single large computer than for several small machines. (It was noted in annex I, paragraph 21 that doubling the cost of an installation yields approximately four times the productive capacity);

(*b*) Operating and overhead costs, planning, space and salaries, for example, are proportionately less for centralized facilities;

(*c*) It is easier to maintain level, balanced work-loads in a large multi-purpose installation;

(*d*) Better use can be made of a single pool of trained manpower;

(*e*) It is easier to build towards integrated information systems (see annex I.B.2).

In favour of decentralized computer facilities the following aspects may be suggested:

(*a*) Greater independence of tasks and better opportunities to apply priorities and build up specialized operations;

(*b*) Less delay and lower costs for data transmission;

(*c*) Greater protection against breakdown of machines;

(*d*) Work done closer to where the results are needed.

83. The advantages and disadvantages of each system are such that it is impossible to say that either policy is preferable in all cases. Those factors which determine government policy concerning centralization *versus* decentralization in general, namely geographical considerations, cultural differences and variations in the availability of manpower, will also be important for computers. In countries where communications are well developed it is becoming possible to achieve both the economies of centralization and the advantages of decentralization by linking remote facilities, but this option is seldom open to developing countries as yet.

84. The above discussion concentrates on the service bureau type of computer centre. Attention should be called to the research computing centre. An example, supported by the United Nations Development Programme (UNDP) is that of the Computing Research Centre in Bratislava, Czechoslovakia. This Centre has established liaison with the University of Oslo and, more recently, with the University of Texas where similar equipment is installed and which are able to act as a source of visiting staff and of computer programs.

Computer installations

85. Computer systems range through large and intermediate to small systems (see table 2). Recently a number of companies have been offering "mini-computers". These are satisfactory for certain areas of scientific or engineering computation and can be very useful in teaching, especially for a university or country where computer technology is in the initial stage. Since they have no significant capability for data handling and printing, they cannot be used for the data processing and administrative applications which must be possible where computers are to be used for development.

TABLE 2. EQUIPMENT AND CAPABILITY OF COMPUTER SYSTEMS OF VARIOUS SIZES

	System		
	Small	*Intermediate*	*Large*
Input	Card reader 80-200 CPM[a]	Card reader 1,000 CPM[a]	Several card readers 1,000 CPM[a] each
High speed memory	8,000-32,000 characters	64,000-256,000 characters	More than 256,000 characters
Disk memory	0-1,000,000 characters (bytes)	1,000,000-30,000,000 characters	More than 30,000,000 characters
Magnetic tapes	0 or 1 unit	2 to 4 units	More than 4 units
Printers	200-600 LPM[b]	600-1,000 LPM[b]	2 or more at 1,000 LPM[b]
Communication capability	Possible	Yes	Yes

[a] CPM = cards per minute.
[b] LPM = lines per minute.

86. Currently, a small data processing system costs about $100,000 and includes a line printer, a card reader and at least one magnetic tape or disk. The cost of the intermediate system ranges from $500,000 to $1 million. It has faster card readers and line printers, more memory (core, disks, and magnetic tape) and a faster central processor. Large-scale systems cost more than a million dollars. Such installations will only be of interest at the operational or advanced stages. The relation between the performance and the size of a computer is discussed briefly in annex I, paragraphs 19 to 22.

87. A computer should have the capacity to process the initial work-load in one shift. Because of the relatively high capital investment, computers are operated during evenings, nights and weekends when necessary; up to four shifts are possible[8] if weekends are included. One of the striking differences between installations in developing countries and those in industrially advanced countries is that the former are often underutilized while the latter are often operating near capacity. This is because the technological growth rate is always very slow at first.[9]

Total cost of a computer centre

88. In too many cases computer centres have been set up without adequate operating budgets. No provision has been made for programming advisers or for key-punch operators or other persons to help in

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[8] Because of the requirements for such factors as maintenance, system changes and fault correction it is very difficult to achieve even as much as three shifts of productive operation.

[9] International Bank for Reconstruction and Development, *Partners in Development: Report of the Commission on International Development* (New York, Praeger, 1969), viii (5).

the preparation of the data, always an important part of the work of a government computing facility.

89. The main costs associated with a computer centre may be listed as follows:

Investment costs:

- Feasibility study
- Construction or modification of a building, including installation of air conditioning, power service, false floor for computer cables, storage for cards, magnetic tapes, work space for users etc.
- Purchase of computer, furniture etc.
- Purchase of computer software
- Shipping and installation costs
- Initial complement of maintenance parts
- Taxes (custom duties)
- Data conversion
- Initial training
- Any appropriate capital costs (depreciation, amortization etc.)
- Contingencies

Operating costs:

- Personnel costs:
  - Director, manager, personal assistant, typing and clerical help
  - Systems and application programmers
  - Operating and consulting staff
  - Key-punch staff
  - Maintenance staff
  - Janitorial staff
  - Education and training of staff
- Supplies and recurring expenses:
  - Electric power and water (also for air conditioning)
  - Paper, cards, magnetic tape and disks, and spare parts
  - Rental costs for leased equipment
  - Publication and mailing costs
  - Costs for library materials (journals, texts, computer programs etc.).

90. Even "free" software has implicit costs. The centre has to assign staff time to communicate with the supplier, see that the program runs properly on the local hardware, teach users about the programs and be able to adapt them to the local configuration. A computer centre must be prepared to put much of its resources into software and into service aids for its users. A computer centre even of modest size needs several systems programmers to keep the system up to date by installing new systems, languages, updates, releases and so on.

91. In commercial installations the budget for personnel and supplies can be twice the hardware costs. In educational installations the budget is less than this, because the applications programmers are faculty members and students, not, properly speaking, staff of the computing centre. Any centre with a large service bureau will operate in the

same way, but even there the annual costs for salaries, supplies and services will at least equal the hardware costs. In developing countries the ratio of hardware to staff costs will be higher than it is in industrially advanced countries. A significant budget will be needed for program advisers, for publishing a newsletter for users, for messenger services and the like.

92. The hardware vendor may contract to provide maintenance, although some installations in developing nations choose to do their own maintenance. In any case it will be necessary to maintain a supply of spare parts, and to know the vendor's techniques for fault detection.

Financing of computers

93. Computer manufacturers offer their equipment both for purchase and for rent, and computers are rented perhaps more often than any other type of capital equipment. There are good arguments both for purchase and for renting.

94. A comparison of costs shows that, for most types of equipment, in about four and a half to five years the amount paid out in rental will equal the purchase and maintenance costs. Thus if it is expected that the equipment will be used longer than five years, it would be preferable to purchase it. Moreover, with a purchased machine the hourly cost of operation decreases significantly as use extends into shifts beyond the first, since the capital costs have already been paid and only the marginal operating costs have to be met.[10]

95. In favour of renting as opposed to purchasing the machinery is the fact that computer technology has been changing so rapidly that machines have quickly become obsolete. Even if they do not become obsolete, in many situations the growth in their use is very rapid (a doubling every two and a half to three years is common) and if the pace quickens further, a country may find that it is outgrowing its computer installation and is faced with an expensive upgrading of a purchased machine.

96. Against the above arguments for rent instead of purchase there are the counter-arguments that third generation hardware, together with the associated software, is likely to last longer than earlier models; and that it takes two or three years even to achieve efficient operation, and replacement times of less than five years are not economical. These reasons, among others, led the Government of the United States to adopt a general policy of increasing the proportion of purchased machines in the United States.

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[10] The reduction in the hourly operating costs for second and third shifts is not as great as is sometimes argued. Besides additional costs for power, air-conditioning, supplies and operating staff, there are costs for maintenance and wear on mechanical equipment which are probably proportional to the hours of use. Moreover greater use means greater requirements for user services, and a larger variety of system demands. Nevertheless it remains true that the marginal cost of computer time, in common with that of most production processes, decreases as the system becomes more heavily loaded.

97. In industrially advanced countries another alternative has emerged whereby leasing companies, acting as a third party, buy a computer from a manufacturer and rent it at rates lower than those quoted by the manufacturer. They are able to do this because they undertake to place elsewhere equipment which has become too small for a particular user,[11] and since the original manufacturer provides the maintenance, there is no loss in the quality of service. Some countries may find it advantageous to form a national leasing company, whereas in other areas of the world a regional approach may be desirable.

98. Altogether, the complexities of financing computers are such that it would seem highly desirable to have a place where developing countries could obtain advice on these matters.[12] This is especially necessary since the cost benefits of computers will be different in developing countries, where the labour markets differ from those of industrially advanced countries (see section VII). To have the full range of opportunities, it would also be desirable to find some way of having leasing options extended to developing countries, which so far have rarely, if ever, had this choice.

99. It is often suggested that developing countries install older, second generation computers, but there are arguments against this. First, the equipment is already obsolete when it is removed from service in the developed country, and, therefore, the centres using it will not have the latest capabilities. Secondly, the serviceability of older computers is much less than that of new hardware. Sometimes it has been so poor that maintenance has cost more than the price of new modern equipment and in some cases, spare parts may no longer be available. Thirdly, consulting help may not be available, because people are no longer familiar with the old software. Finally, since in the long run most of the money spent on a computing centre will be for salaries and software, and since the value of the software for older equipment is much less, due to its reduced life expectancy, the real savings will be much lower than the apparent savings.

100. A case for installing older equipment can be made, especially if the cost is low enough, say one third to half of the original purchase price. Transistored "second generation" equipment may continue to be reliable over an extended period, and older machines may come with a very useful collection of routines. However, many developing countries are not prepared to accept the suggestion that equipment no longer considered to be adequate for an industrially advanced country is good enough for them. The ACAST Working Group noted that the arguments against older equipment are generally convincing; there may, however, be particular circumstances in some countries where an exception is in order (see annex V, paras. 14-15). It is clearly necessary for any institution which is considering installing older equipment to examine all aspects of the proposal carefully.

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[11] Furthermore, the manufacturer has other clear choices for funds which are invested in a rented machine and this adds to the rental.

[12] The need for such advice to be made generally available was emphasized by the ACAST Working Group (annex II, para. 15).

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Dissemination of computer information

101. As is the case with every branch of technology, information about computers is being generated at an accelerating rate, and there are problems involved in making it available to developing countries. There should be at least one national centre with a good computer library in each country; further, each computing centre will need literature about its own equipment and about applications which are locally important.

102. The literature on computers has an archival component (periodicals, research journals, review publications and the like), and a current awareness component (publications which list the contents of research journals, reports and evaluations of new equipment etc.). In addition there is information which might be classified as ephemera (notices of meetings, conference programmes, notices of software packages, announcements for books, courses and training programmes and so on). Developing countries certainly need a good selection of the archival material about computers, just as they do about other aspects of technology. Methods of financing such acquisitions should be explored, for example, through the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the professional societies. The current awareness material is also valuable, and here the acquisition problems are even greater, for they are usually offered on subscription for rates which can be prohibitively high. A possible solution which would make at least the ephemera available might be to convert this material to microform, that is to print it on microfiches or microfilm; it would then be possible to mail the equivalent of a hundred pages or more of printed material at a rate comparable to that for a postcard. The information contained in the ephemera will be useful to people in developing countries, for it provides an awareness of what is going on in the discipline, makes it possible to order conference reports and instructional materials as soon as these become available, and in general can impart a sense of participation in current activities. Since there are no copyright problems with such material, and there will be no costs for selection and classification (as the material would not be retained more than a few weeks), costs should be low. This type of distribution might be undertaken, for example, by a university in a developed country which is already circulating the material as part of its own library operation.

"Twinning" and bilateral links[13]

103. The field office of a computer manufacturer often does not have good communication with the central office. It is difficult for a computer centre in a developing country to learn about or acquire

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[13] For a general discussion of this subject, see United Nations Educational, Scientific and Cultural Organization, *Bilateral Institutional Links in Science and Technology*, "Science policy studies and documents", No. 13; also document E/AC.52/L.82.

software packages. One solution already mentioned in this report is to set up a "twinning" relationship or a bilateral link with a similar installation in a developed country: that installation could undertake, *inter alia,* to collect and send information and software packages to the institution in the developing country. For this system to be most effective the "twins" should have equipment made by the same manufacturer and similar responsibilities within their respective countries for such functions as operations and teaching. In view of the problems of foreign exchange, it may be argued that the costs of the "twinning" services should be absorbed by the budget of the centre in the developed country; but to ensure that the materials sent are always useful, and to encourage an economically viable service it may be better to budget the costs in the developing country. However, a viable arrangement requires extra resources for the institution in the developed country, as altruistic services tend to lapse.

104. Among the reasons why "twinning" is attractive is that it provides a means of personal concern and involvement for people in both developing and developed countries and may be a means of bringing institutions with similar equipment, problems or experience closer together.

IV. THE ACTIVITIES OF THE UNITED NATIONS FAMILY OF ORGANIZATIONS IN THE APPLICATION OF COMPUTER TECHNOLOGY FOR DEVELOPMENT

105. In this section are described the various activities which have for many years been undertaken in the United Nations family of organizations with respect to the application of computer technology for development. These activities involve two substantive divisions of the United Nations, the United Nations Industrial Development Organization (UNIDO), the International Labour Organisation (ILO), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the World Health Organization (WHO) and the World Meteorological Organization (WMO), in addition to the United Nations Development Programme (UNDP) and the International Bank for Reconstruction and Development (IBRD), who are providing support for a number of projects with a computer component. United Nations Institute for Training and Research (UNITAR), Food and Agriculture Organization of the United Nations (FAO), International Telecommunications Union (ITU), and International Atomic Energy Agency (IAEA) also have an interest in the field of computer technology from the point of view of their particular areas of activity.

106. Almost all the organizations of the United Nations systems, including the regional economic commissions, use computers for internal administrative purposes or to fulfil their statutory obligations; in some cases the use is extensive. The benefits arising out of these applications can serve developing as well as industrially advanced countries. Many United Nations and other international organizations are also mechanizing the collection of the data needed for their operation. Many of the organizations of the United Nations family have computer facilities of significant power; among these are the installations at United Nations Headquarters in New York in the International Computing Centre, those of the ILO and WHO in Geneva and of UNESCO in Paris. In most cases there is a willingness to do computing work for developing countries. Many of the organizations have plans for expansion. Such plans inevitably raise questions as to the best way of avoiding duplication of costly investments, a problem which, as already noted, also arises with the expansion of computing facilities in national governmental agencies. The plans of the United Nations family of organizations in this connexion are currently being reviewed and it would be beyond the terms of reference of this report to comment on them.

United Nations

107. Within the United Nations Secretariat two substantive divisions, the Statistical Office and the Public Administration Division co-operate to provide advice on the effective use of computers, support experts and conduct training programmes. Some forty-two man-years of expert advice in this field have been provided to twenty countries over the last twenty years, 90 per cent of this assistance having been provided in the last ten. In addition, over five man-years of regional and interregional adviser services have been provided, mostly involving short-term missions. Persons from the developing countries have been trained through fellowships and orientation services, and since 1961 over fifty fellowships have been granted to students from twenty countries. *Orientation Course in Mechanized Data Processing,*[14] one of several publications since 1964, has been translated into French and Spanish and used widely by public administration institutes co-operating with the United Nations. The assistance (provided by the United Nations) has been directed to the public sector as a whole.

108. In addition to the efforts described above, the Statistical Office has been using computers for the collection and standardization of economic statistics. Prior to 1966, the use of computers was on a contractual basis with service organizations. In November 1965, computers were installed at the United Nations Headquarters in New York and a new section of the Statistical Office was formed: the International Computing Centre. Through the use of these computers, the Statistical Office has been able to establish and operate data banks in such fields as external trade statistics, national accounts statistics, demographic statistics, and industrial commodity production statistics and make them available for economic analysis, projections and planning to other divisions and offices within the United Nations, to the specialized agencies and to Governments and other institutions. The International Computing Centre has also engaged in on-the-job training of fellows in the management of data processing installations and the use of computers for statistical data processing. To date, this work has been experimental in nature and small in scope but, as time and resources permit, it is expected that greater effort can be devoted to this type of training.

United Nations Educational, Scientific and Cultural Organization

109. United Nations Educational, Scientific and Cultural Organization is carrying on a broad range of activities in the field of computer sciences, in co-operation with universities in the developing and industrially advanced countries.

In brief, these activities encompass:

Science: the training of personnel, promotion of international co-operation, study of computers as research tools in science policy, hydrology, oceanography and similar disciplines;

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[14] United Nations publication, Sales No.: 66.II.H.3.

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Education: the use of computers for educational administration, planning and instruction;

Communication: documentation research and training, library automation, computer models for education, scientific and technical manpower;

Social sciences, human sciences and culture: the use of computers for social science research and documentation.

110. The proposed UNESCO budget programme for 1971/72 contains a recommendation that the Director-General be authorized to continue to promote research in the basic sciences, in particular with respect to computer sciences.

International Labour Organisation

111. For over seventeen years the ILO has, with UNDP support, assisted in setting up management development and productivity centres to provide training in management, consultancy and computer technology; this has in four cases involved the creation of electronic data processing units.

112. In response to numerous requests from other centres to develop computer training divisions, the ILO recently initiated a new programme; "Computer training for management". Studies by the ILO in developing countries revealed the following problems: the need for improved management practices to accelerate industrial growth; insufficient knowledge of the proper use of computers; a proliferation of computer installations, many of which are not used to their full potential; a scarcity of management systems analysts to link management to computers. To resolve these problems the ILO proposes to train managers in the use of computer-based management information systems (MIS) to aid decision-making, and to train systems analysts to develop such systems.

113. On the basis of past experience, the ILO seeks in its new programme to reduce the time and effort involved in developing MIS, by designing general purpose systems and related documentation which can be readily adapted to individual enterprises in many countries. International experts would guide national counterparts in training and in the applications of MIS. Before the arrival of experts on projects, national staff would receive training at a central institute. This would reduce the amount of guidance required from experts, and permit the projects to develop MIS applications more rapidly.

World Meteorological Organization

114. In response to General Assembly resolutions 1721 (XVI) and 1802 (XVII), the World Meteorological Organization has established and is now carrying out its World Weather Watch programme —a global plan for the application of modern scientific and technological developments designed to enable all countries to derive full economic benefits from improved meteorological services. This programme comprises a global data processing system and a global telecom-

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munication system, both of which include the use of computers by world, regional and national centres and telecommunication hubs.

115. Assistance for developing countries in obtaining computer facilities in support of the World Weather Watch is available through UNDP and the Voluntary Assistance Programme of WMO. The support to the Regional Meteorological Telecommunication Hubs at New Delhi, India and Prague, Czechoslovakia are examples of assistance under the latter programme. At its headquarters in Geneva, WMO is processing information needed for the operation of the international programme established by it. It prepares its information by computer and also provides operational information required for the World Weather Watch on digital carriers for ready use by the individual countries using their computing facilities.

World Health Organization

116. Since 1964 the following activities have been undertaken by the World Health Organization:

Conference on the application of ADP systems in health administration, organized by the WHO Regional Office for Europe (Copenhagen, 17 to 21 November 1964);

Symposium on the use of electronic computers in health statistics and medical research, organized by the WHO Regional Office for Europe (Stockholm, 6 to 10 July 1966);

Seminar on the public health uses of electronic computers, organized by the WHO Regional Office for Europe (London, June 1968);

Working Group on the Regional Office's activities in the field of medical computing, organized by the WHO Regional Office for Europe (Bratislava, Czechoslovakia, 24 to 26 February 1970);

Advisory Committee on computers in health programmes, organized by the WHO Regional Office for the Americas (Buenos Aires, 13 to 17 April 1970); The establishment, in collaboration with UNDP, of the Central Institute of Public Health, Sofia, Bulgaria;

Course on electronic data processing in health services, organized by the WHO Regional Office for the Eastern Mediterranean (WHO headquarters, Geneva, 25 May to 3 June 1970);

Expert Committee on statistical indicators for the planning and evaluation of public health programmes (WHO headquarters, Geneva, 2 to 8 December 1970).

117. In addition, in 1967, WHO established the Division of Research in Epidemiology and Communications Science with special responsibilities in the application of computer science to health development.

118. The World Health Organization thus contributes to the training of personnel from developing countries in the use of computers and computational techniques in such areas as epidemiology, international health statistics, medical literature, medical research and public health administration.

United Nations Industrial Development Organization

119. United Nations Industrial Development Organization deals with industrial development at both the macro-level and the micro-level. Computers are mainly being used in industrialization surveys for industrial development planning and programming, programme and project implementation and control and information systems as well as project operation.

120. As regards training in computer application in developing countries, the field of project implementation may provide an illustration. UNIDO gears the training to the application of network analysis techniques for the scheduling, monitoring and control of the implementation of industrial projects including techniques for resource allocation.

121. Computer application in other fields is under study by UNIDO.

United Nations Development Programme

122. From the inception of the United Nations Development Programme Special Fund in 1959 up to March 1970, financial assistance has been approved for twenty projects under which a provision is made for computer applications. The total UNDP allocation for these projects has amounted to more than twenty-three million dollars with the following elements directly related to computer operations:

	US dollars
Expert services in the field of computer applications (software)	3,430,000
Training (mainly for fellowships) in computer-based data processing	726,000
Computer equipment (hardware)	4,200,000
TOTAL	8,356,000

123. Of these twenty approved projects, six are in the field of flood control and water resources, six are management training centres, five are computing centres, one is a hydrometeorological institute, one is in the field of public health and one in natural resources. Their geographical distribution is as follows: Europe, nine: Asia and the Far East, five (including one regional); Africa, four (including two regional), the Middle East, one and the Americas, one. Six of these projects are executed by ILO, five by UNESCO, four by the United Nations, two by FAO and WMO respectively and one by WHO.

124. In addition to the above support, UNDP is also providing on request the services of computer specialists under the Technical Assistance component of the Programme.

Contacts with professional computer organizations

125. It may be noted that in establishing and conducting training programmes the United Nations family of organizations has had very little contact with the national and international professional organiza-

tions in the computer field, where a large body of expertise resides. For example, announcements about the courses in professional journals have been infrequent and the societies have rarely been called on for help in setting up courses or finding persons to aid in teaching them. Although there have been some contacts with educational institutions, these have not been extensive. One result is that curricula have not benefited from constant review by those actively engaged in the profession. Another is that the search for persons qualified to teach courses is probably not carried on over a sufficiently wide base. Chapter eight of *A Study of the Capacity of the United Nations Development System (DP/5)* refers to the problems of recruiting staff for the United Nations; advertising in the journals of professional computer organizations would help when instructors and other staff are needed for computer training programmes. Section VI of the present report contains a recommendation concerning co-operation with the professional bodies.

V. OTHER INTERNATIONAL EFFORTS

Governments, educational institutions and foundations

126. A vital component of foreign aid in the field of computer technology is the support of research and educational institutes in developing countries by Governments and foundations. Often the aid takes the form of contracts to universities from industrially advanced countries to conduct educational programmes in developing countries. Also common are contracts to build computer models and simulations of important sections of the economy in developing countries.

127. In India, there are five institutes of technology, supported respectively by the United Nations, the Federal Republic of Germany, the Union of Soviet Socialist Republics, the United Kingdom and the United States. In all cases the support is for the institute as a whole; sometimes included are funds for computer facilities or computer projects. For example the Ford Foundation support for the engineering programme in Santiago, Chile, included funds for the computer centre, and the support of the same Foundation for the agricultural programme in India included subsidies for establishing computer centres both in the Government and in universities. The Rockefeller Foundation has sent computer experts to the University of Ibadan in Nigeria.

128. Universities in the industrialized countries are obvious candidates for "twinning" (see paras. 103-104) with universities in the developing countries and this type of pairing has been in effect for some time. Aid may take the form of the loan of academic staff, planning of curricula, or provision of teaching materials or research guidance. It should be noted that universities will not be the most appropriate choice for pairing with national or regional centres of the type discussed earlier, where there must be an emphasis on data processing, and computing for government administration.

129. Even a large university can have difficulty in finding enough staff to carry out the extensive programme which should be mounted if the institution in the developing country is to reach a threshold beyond which it can carry on for itself. To overcome this difficulty in the establishment of the Indian Institute of Technology at Kanpur, a nine university consortium, financed by the United States Agency for International Development (AID) was set up. Over a period of years these universities sent some twenty-five professors to Kanpur each year.

130. The Kanpur computer, a medium-sized machine with punch card input-output, a line printer, and three magnetic tape units, was delivered in July 1963. At that time, three visiting experts in computing were already in India. One of these acted as the director of the

computer centre; another acted as systems programmer in developing, modifying and updating the software; the third concentrated on the academic programme. The three set up short courses aimed at introducing persons from university, government and the private sector to computing. At present, the computer centre is operating successfully. It is an essential part of the academic programme and also carries on administrative computing. It is completely staffed by Indian nationals.

131. The need to strengthen research and educational institutions in developing countries was emphasized repeatedly in the replies of Governments to the Secretary-General's questionnaire. It can be strongly argued that in furthering research emphasis must be placed on those aspects of the work which contribute to the transfer of technology rather than on research for its own sake. One way of marking this emphasis is to support those computer centres and computer applications which are important for development.

132. Possible sources of support for furthering computer technology in the developing countries may be forthcoming from Canada, through the International Research Development Centre, from Japan through the Japan Computer Usage Development Institute, from Israel and from France.

Intergovernmental Bureau for Informatics—International Computation Centre (IBI-ICC)[15]

133. The IBI-ICC was created as an international computer centre under the auspices of UNESCO in pursuance of a series of resolutions dating back to October 1946, but it did not actually come into being until November 1961 when ten States members of UNESCO ratified the International Convention bringing it into operation. The member States provide funds according to a scale of assessments proportional to the contribution paid by each to UNESCO. The organizational structure consists of a General Assembly, an Executive Council, and a scientific and administrative staff with a Director at its head. It is located in the Viale della Civiltà del Lavoro, Rome. The General Assembly which meets every two years, consists of a representative of each contributing member State and a representative of UNESCO. The Executive Council which ordinarily meets twice a year, consists of six members elected by the General Assembly and a representative of UNESCO. The Director is appointed by the General Assembly for a four-year term which may be renewed.

134. The IBI-ICC was conceived at a time when many people felt that high speed computers would be large and expensive and that joint action by many countries was needed to acquire and operate a facility which would serve developed and developing countries alike. This kind of co-operation has of course been necessary with regard to high energy accelerators in physics, and the Centre d'Etudes et de Recherches Nucléaires (CERN) facility in Geneva is an outstandingly

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[15] See also annex II, paragraph 10.

successful example of international co-operation in that field. But computer technology has evolved differently. The cost of computers is not comparable with that of large accelerators and—what is equally important—computers soon became necessary not only for research, but also for performing efficient operations in a great many activities. The result was the establishment of a market for computers of many sizes and it became possible, and necessary, to have not one but a number of computers in every country.

135. The IBI-ICC was slow to react to the change. It expended a great deal of effort in its early days on acquiring and operating a computer facility which in the end proved to be only of marginal value to its members. Although the initial contacts, through UNESCO, with the international computing fraternity were profitable, there was difficulty in maintaining them. The International Federation for Information Processing (IFIP) grew up independently and absorbed many of the tasks of providing an international clearing house for computer information and of sponsoring international conferences. Membership in IBI-ICC did not grow at the expected rate, leaving it chronically short of funds, and this was both a cause of and compounded by staffing problems.

136. In 1969, the Fourth General Assembly of the International Computation Centre modified the objectives of the Centre so as to make it an intergovernmental bureau for information processing rather than computation, and in accordance with this modification the name of the organization was changed to the "Intergovernmental Bureau for Informatics". This organization is now undertaking to promote the use of information processing at governmental levels through a variety of means, which include sponsoring and conducting education programmes in developing countries in the language of the region. It is also offering to provide a permanent address and secretariat services for international professional bodies and other organizations concerned with information processing.

Private sector contributions

137. Developing countries are bound to have difficulty in deciding how to react to offers of help from companies in the private sector. The record shows that many private companies are prepared to make highly desirable long-term investments of capital in the education of nationals. The importance of the initiative of the private sector in the growth and application of computer technology merits particular recognition, a point also mentioned by the ACAST Working Group (see annex II, paras. 11-12). The Group further stressed the developing countries' need for an authoritative source of independent, disinterested advice in dealing with the private sector.

138. In the computer field, manufacturers send technical and sales personnel abroad on training programmes and courses, often for appreciable periods of time. The computer market, in which one company exercises considerable influence in the world, is highly competitive, and

it is natural for developing countries to take advantage of offers which fall within normal marketing practice, for example, technical assistance in the form of visiting experts. Some companies are prepared to go beyond this by bringing in experts, or arranging for tours (usually by decision-makers) of computer sites even when there is no immediate prospect of a sale. Computer manufacturers contribute to the evolution of the technology by encouraging their employees to participate actively in professional societies. This contribution is not disinterested, but it is valuable. In Latin America it is often the custom for professors to have only part-time appointments in universities; they also are employed by consultant, engineering and manufacturing companies. This connexion between the universities and companies in the private sector has resulted in a vigorous computing industry, not surprisingly with a heavy emphasis on business data processing.

139. Paragraphs 198 to 201 of section IX of the present report suggest ways in which computer (and software) manufacturers might make contributions to developing countries by relaxing the restrictions on the distribution of software. The large educational discounts for computers, which were available to universities in industrially advanced countries for a long time, have without question been an important factor in the widespread penetration of computers into the educational world. The discounts have been reduced to the point where they are no longer significant, but in industrially advanced countries computers are now firmly established in universities so that the effects of the policy change will probably not be severe. Computers are not yet as prevalent in the educational institutions of the developing countries. The reduction of educational discounts and the withdrawal of special arrangements for acquiring computers have not yet been applied as completely there and it is hoped that manufacturers will continue to recognize the case for maintaining these concessions.

140. Help should be expected not only from the computer manufacturing companies in the private sector but also from consulting and software companies and from companies which use computing equipment. These companies have also contributed to the growth of their national computer societies, for example by allowing their technically qualified people to participate in them; this is important because those organizations need members from all relevant sectors of the computer industry.

141. The initiative of the private sector is an important factor in the growth and application of the computer technology. Under conditions that are equally attractive to Governments of the developing countries and to companies in the private sector, the expertise and goodwill of the private sector can be brought to bear on the problems of development.

Professional organizations

142. Both national and international professional organizations may be available for providing technical assistance in bilateral and

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multilateral programmes. National professional computer organizations with members from among computer and software suppliers, from among government and commercial users and the educational community render valuable service to the computer technology. The organizations maintain a large network of special interest groups, task forces and committees whose members possess considerable expertise. Government bodies and organizations in the United Nations family do not draw upon them as often as they might. Clearly it is not proper to ask a professional body to carry out a task which might conflict with its own interests; but a professional body can recommend individuals who can advise on the selection of equipment or give an opinion about a consulting organization.

143. There are many other tasks they can do effectively. In several countries the national professional bodies conduct censuses on the number of persons engaged in the computer industry, and on current salary scales. Very often these surveys yield the most accurate statistics there are on the computer industry. These statistics are of obvious help in planning government policy. All national organizations have the education of their members as a goal, and they sponsor courses, hold technical and educational sessions, bring in visitors and conduct visiting lectureship programmes. Their most important contributions, however, are the scientific and technical journals which appear in many countries and in several languages. This computer literature has been of central importance in the emergence of computer science (*informatique*) as a discipline and a profession.

144. National professional groups may be a good source of advice concerning government legislation related to computers. It is particularly relevant to this report that some national organizations in industrially advanced countries have begun to take an interest in helping developing countries. The American Federation of Information Processing Societies, for example, has recently funded a computer internship programme.

145. The international professional organizations have the same aims as the national ones, with international co-operation as an additional objective. The International Federation for Information Processing (IFIP) and the International Federation of Automatic Control (IFAC) (see annexes VII and VIII) have undertaken to assist developing countries. The Intergovernmental Council for Administrative Data Processing (ICA) (see annex IX) is also concerned with helping the developing countries.

146. Among the tasks which international professional organizations could perform are the following:

(*a*) Nomination of representatives to serve on the international and regional advisory boards. This is potentially the most important service they could render; if the representatives are energetic in their participation they will soon become involved in such activities as seminars, advice to Governments on organizing facilities, fellowship programmes and "twinning";

(*b*) Provision of financial help to make technical publications available to members of developing countries, under appropriate conditions;

(*c*) Maintenance of an active roster of experts available for consultant services, short visits or extended stays. This list should be brought up to date at least once a year;

(*d*) Arrangement of sessions of interest to developing countries in the international symposia, and sponsorship of persons from those countries to attend the sessions;

(*e*) Arrangement for some conferences and technical meetings to be held in the developing countries;

(*f*) Support for the translation of texts and important books on computer technology into different languages.

147. The involvement of some professional organizations in the preparation of the present report may be taken as an indication of their responsiveness to the above.

VI. AN INTERNATIONAL ADVISORY BOARD ON COMPUTER TECHNOLOGY FOR DEVELOPMENT

148. Even in those parts of the world where the greatest number of computers are installed, the rate of growth and application of computer technology shows no sign of slowing down. There is a strong desire on the part of the developing countries to increase their participation in this rapidly developing technology so as to assist their development in an economically feasible manner. Considerations concerning the types of policies and programmes for the application of computer technology in the developing countries themselves are discussed elsewhere in this report. At the international level, the Panel of Experts and the ACAST Working Group concluded that an instrument is needed to stimulate the realistic and sound development, application and adaptation of computer technology with particular reference to the conditions found in the developing countries. Such an instrument would take into consideration the work already being done in the United Nations family of organizations and elsewhere. Much experience has already been gained and there are many lessons that may be learned from this experience in both the developed and the developing countries; it can be drawn on still more intensively and the duplication of efforts can be minimized wherever possible.

149. For the achievement of above objectives the following activities may be suggested:

(*a*) Promoting international co-operation in computer activities related to development;

(*b*) Formulating strategies to accelerate the process of development through the application of computer technology;

(*c*) Recommending policies with regard to the application of computers for development for the United Nations family of organizations and for the developing countries;

(*d*) Providing the developing countries with methods for obtaining assistance in all aspects of information processing and computer technology, and reviewing proposals, if requested;

(*e*) Co-ordinating, for United Nations supported activities, programmes and projects on computer technology for development;

(*f*) Sponsoring, promoting and supporting activities of the United Nations and the United Nations family of organizations as well as those of national and other interested organizations related to computers for development;

(*g*) Advising on computer activities supported by the United Nations and its family of organizations, as requested;

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(*h*) Involving the major international professional organizations as well as the principal international user bodies concerned with computer technology.

150. To achieve these tasks, the Secretary-General believes that the General Assembly may wish to consider the proposal made by the *Ad Hoc* Panel of Experts and supported by the ACAST Working Group[16] for the establishment of an international advisory board on the application of computer technology for development. Such a board could report annually to the Secretary-General who would submit the report for consideration by the Economic and Social Council and the General Assembly. Two broad types of function might be envisaged for this board:

(*a*) To promote the application of computer technology for development through international co-operative efforts in association with the United Nations family of organizations;

(*b*) To provide, upon request, independent and objective advice to assist the developing countries in their decisions on the use of computer technology for their development.

151. It might be envisaged that the board be appointed by the Secretary-General for a period of three years and meet twice a year. In view of the important role played by UNDP in supporting activities in this field, the Secretary-General would consult with UNDP in this matter. The membership of the board might be envisaged as consisting of twelve experts appointed in their individual capacity by the Secretary-General in consultation with UNDP; representatives of major international professional organizations such as IFIP and IFAC and other particularly user-oriented bodies deemed appropriate by the Secretary-General and UNDP; and representatives of organizations in the United Nations family, including IBRD.

152. In the view of the Panel of Experts and the ACAST Working Group the board must have strong connexions with the international professional computing community through its representatives from such bodies as IFIP and IFAC.

153. The presence on the proposed board of persons of independent judgement, not influenced by existing jurisdictional or political considerations should be of great value. It could be a most important means of ensuring that any policies evolved within the United Nations regarding computing for development are realistic and practical, and also that persons who are appointed as directors, visitors or consultants have the international standing and professional competence to carry out the tasks expected of them. It could be hoped that any proposal for large-scale support by the United Nations of a computing activity would not fail to have the benefit of review and assessment by this international board if it were established.

154. The involvement of the organizations of the United Nations family in this proposed board will be conducive to concerted efforts and

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[16] See annex II, paragraphs 1 to 6.

make it possible to draw up the experience of these organizations in their particular spheres of competence.

155. Although there are already persons responsible for some of the functions outlined above in the United Nations system of organizations, United Nations supported institutions or international professional organizations, the scope and importance of the board's activities would make it necessary for it to have its own secretariat of sufficient size to provide services for the board, to facilitate the direct advisory service activities in which the board would be involved and to ensure that it would be fully interrelated with the requirements of the UNDP secretariat. The secretariat would not need to be large, as it would be able to call on outside consultants and make full use of the relevant facilities and expertise of the specialized agencies and the substantive divisions of the United Nations Secretariat. It is envisaged that the secretariat would not need to build up a large operational structure nor should it have a computer facility, for it would be able, as required, to call upon needed resources from facilities within the United Nations system or from other organizations.

156. The ACAST Working Group in its report mentioned its own involvement in an examination of the machinery in the United Nations family for dealing with the application of science and technology for development and stated that the proposed international advisory board and its supporting secretariat reflected the Advisory Committee's opinion that the United Nations machinery must be adapted to the needs of the changing technology and be able to provide the central policy role and the leadership which that changing technology demanded. The Committee considered this to be particularly true if the developing countries were to feel that there was a central point for efforts to encourage the realistic application of the newer technology to their development (see annex II, paras. 1-6).

157. Consideration has been given to meeting regional needs and Governments within a region may wish to consider the desirability of establishing a regional counterpart to the proposed international advisory board on computer technology for development, which should be associated with the corresponding regional economic commission. These regional boards should have representation from the region as well as some members cross appointed from the proposed International Board. The professional bodies and the United Nations organizations should also be represented.

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VII. STRATEGIES AND EXPECTATIONS

158. Previous sections of the present report have concentrated on computers in their own right. But the computer technology is only one aspect of the technological activity of a country and in planning its growth it is necessary to relate it to other technological factors and to general national goals and programmes. In this section some of these relationships are examined.

Levels of computer activity

159. As a preliminary step to studying how the growth of computer usage can be encouraged to keep pace with and promote general technological growth, it may be helpful to classify countries according to their use of computers. For this purpose, a four level classification has been drawn up as follows. The ACAST Working Group expressed the opinion that this concept of levels would be useful (see annex II, para. 17).

Level	*Characteristics*
Initial	There are no operational computers in the country. A few nationals have had contact with computing. The only local sources of information are computer salesmen.
Basic	There is some understanding of computers in government (and private) decision centres. A few computer installations are to be found. There are some nationals involved in computer operations. There is some education and training in computer technology in the country. Computers are used in basic government operations.
Operational	There is extensive understanding of computers in government (and private) decision centres. Among the numerous computer installations there are some very large machines. There are centres for education and training in computer technology and some are of excellent quality. They offer degree programmes in computer or information science. There is design and production of software and some manufacture of hardware. Computers are affecting many disciplines, particularly science, engineering and medicine.
Advanced	Most government and administrative work is carried out by computers. There are well established professional activities and national meetings on computers. There is a complete range of quality education and training programmes. The number of computers, of all sizes, is increasing rapidly. Time-sharing, teleprocessing and remote job entry are common. There is design and production of both hardware and software. Many technologies have been changed or are in the course of being changed. New applications of computers are found regularly. There is strong participation in and contribution to international activities.

160. It will, of course, be obvious that the dividing lines between classes are not well defined and a country may be on one level with respect to certain characteristics and on another with respect to others.

161. At the first or initial level there is little computer activity and particular emphasis will be placed on methods of assisting countries in this category.

162. At the second or basic level there are nationals in the country who have been trained abroad and understand the problems of establishing a computer service. Often the first computing centres in a country are established and managed by foreign corporations who give training abroad or on the job. The pay may be above the local average scale, with the result that there will be little transfer of trained people to other installations. Such computer centres do not contribute to the capability of the country in the same way that national or university centres do.

163. The third level is operational. For countries in this category there are numerous well-run computer centres and many people who can give objective advice. At this stage the country is not dependent on the advice of salesmen; the source of information has moved to educational institutions and national or governmental computer sites.

164. The last category is advanced. Here many types of computers are widely used in industry, government and educational institutions. Technical meetings are held frequently and publication of computer information is extensive.

Upgrading the level of computer technology

165. What should countries do to move from one level in computer technology to another—from initial to basic, basic to operational, and operational to advanced? Clearly for countries at the initial level a national computer centre is needed as soon as possible and, until one is available, good access to a regional facility is essential.

166. The first emphasis should however not be placed on the computer itself. It must be on formulating a broad national policy where the role that the computer technology is expected to play in achieving national goals is made clear. From this policy will follow detailed planning, such as the selection of priority applications for computers. Such applications may be to the population census, or to some part of the governmental financial system. In general, applications which can make the maximum contribution to raising the socio-economic level of the country should be sought. The planning will have to include a determination of prerequisites, such as better information, which must be met if the application is to be carried out, and allocation of necessary resources. After priority applications are selected there will have to be detailed systems analyses in which specific requirements are defined, alternatives are investigated and needs for personnel and equipment set forth. As seen in figure III, education will be a prerequisite of every stage of the sequence which leads to the actual implementation of a

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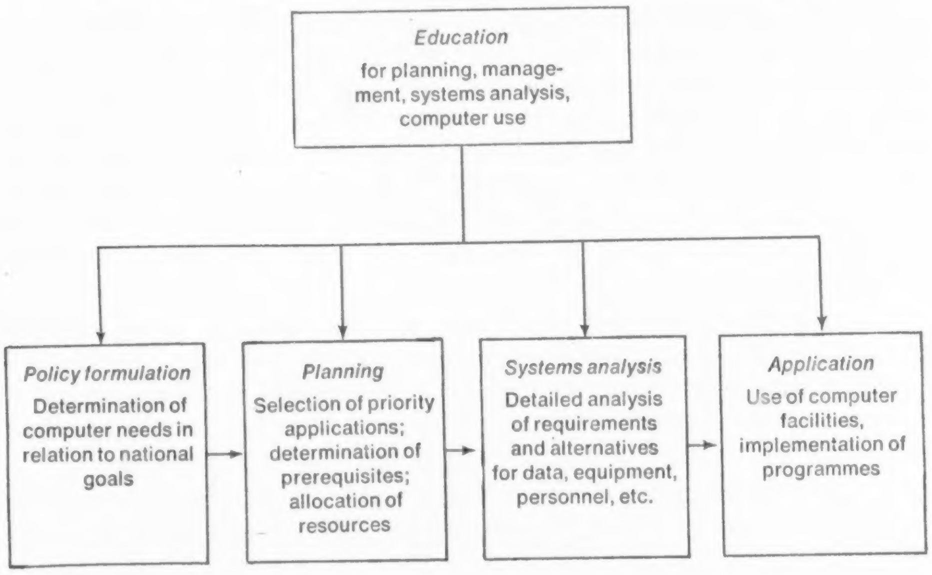
computer application important to national development. When a developing country has been able to execute this sequence, even once, for itself, it will be beyond the initial level of computer use.

Figure III. Sequence for applying computers to development


Education
for planning, management, systems analysis, computer use
Policy formulation
Determination of computer needs in relation to national goals
Planning
Selection of priority applications; determination of prerequisites; allocation of resources
Systems analysis
Detailed analysis of requirements and alternatives for data, equipment, personnel, etc.
Application
Use of computer facilities, implementation of programmes

167. To move to the operational stage, the procedure described above will have to be carried out many times and in many sectors. During some of the repetitions it will undoubtedly be necessary to acquire new computer facilities. But computers should be acquired only as needed; they must not be installed on the basis of a vague notion that they will turn out to be necessary. Initially, developing countries will need advice on how to assess their needs, for which they may wish to turn to the proposed international advisory board and the sources described in section VI.

168. To go from the operational to the advanced level is much more difficult. Widespread educational and training facilities for computing are needed. There must be good educational programmes in applied mathematics, computer science, electronic engineering, management science and similar disciplines. The technology must also be supported by other elements of the technical and scientific infrastructure. There must be a reliable communications system so that remote job-entry and time-sharing computer systems can grow. There must be a viable electronics industry to make it possible to design computer components if not whole computer systems.

169. The action required to move from one level of computer techonology to the next may be tabulated as follows. At each transition the actions are additional to those taken previously.

Transition	*Action*
	Decision-makers and planners must participate in explanatory courses on the background and potentialities of computers. Prospective computing managerial and operating staff must work at regional or nearby national centre, attend conferences, seminars and so on. Advice should be obtained on priority computing applications, hardware selection and the like.
Initial to basic	Small to medium-sized computer(s) should be installed for public administration work. Using available computer facilities, training or educational programmes should be undertaken. A national computer policy should be formulated, consistent with over-all goals. Segments of information system should be chosen for computer implementation. A national training and educational programme should be built up, including the establishment of computer science courses at universities.
Basic to operational	Advanced programmes should be initiated by sending some persons abroad for advanced training, seminars, participation in institutional conferences etc. A computer communication system must be built up. Action is necessary to ensure presence of large computers in the country. Selected software development, for example, applications for nationally important industries, should be encouraged. Professional society activity, including publication, also to be encouraged.
Operational to advanced	Government information systems must be integrated. Elements of hardware fabrications which might be useful should be selected. Computer related disciplines, such as management science and operation research, should be built up. Research should be sponsored and encouraged in computer areas which expertise has developed and to adapt computers to special needs. There must be vigorous national societies in the fields of information processing and automatic control. All these will have to be built up patiently with planning and with help from the industrially advanced countries.

"Leap-frogging": skipping a level of development

170. In bringing a technology into a developing country it is desirable to import the best practices, so that the country can "leap-frog" over earlier stages and gain the advantages of the most modern techniques. To some extent this is possible with computers. It has already been recommended (see paras. 93-100) that developing countries acquire, whenever possible, third generation computers because of their increased reliability, decreased operating costs and more versatile software.

171. There are, however, components of the computer technology which should not be adopted until a great deal of experience has been gained and the most careful preparations have been made for them. At this point it may be useful to review those developments in computers which this report has indicated should not be emphasized initially:

(*a*) The manufacture of computers and their components is becoming a more and more highly automated process. Marketing of computer products is highly competitive and has to be carried out on a world-wide basis. With regard to hardware, the research and investments connected with its production will generally go beyond the present and foreseable capabilities of most developing countries, unless they act on a regional basis or belong to the category which has advanced technological facilities;

(*b*) Time-sharing is extremely attractive to users impatient with batch processing delays, and to those who wish access to computers from their own premises. However, not only are the computer costs higher[17] in this mode, but—even more important—time-sharing systems require a reliable, inexpensive communications network. This is lacking in many developing countries. Until it is available time-sharing should be deferred;

(*c*) As indicated in annex I, paragraph 43 to 50 there are certain types of application which are receiving attention in the industrially advanced countries, but which have not yet reached their potential. Included in these are computer-assisted instruction, on-line management information systems and library automation. These will undoubtedly come into their own. But they are proving difficult to implement even in the industrially advanced countries. Developing countries should not undertake them unless they have special knowledge or skills which are pertinent.

172. Many of the applications of computers will have to be realised in stages. In accounting, it may not be necessary to pass through a manual accounting stage, a unit record stage (involving punched cards, printers, sorters and the like, but no computers) and finally an electronic data processing stage. But it is difficult to conceive of an accounting application being introduced as a completely automated

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[17] These high machine costs can be offset by lower costs for programmer's time.

process, without a prior operation in which the essential elements of the system have been thoroughly tested without the computer. In general, the systems analysis which precedes a computerized application should be based upon, but not copied from, an operational procedure.

173. The widespread use of computers is too dependent on education, always a slow process, to happen quickly. But computers, and the integrated information system which comes with them, will enable developing countries to plan on a national scale, according to national priorities. And they will be able to do this in ways which even the industrially advanced countries are only now beginning to learn. In this respect computers will make "leap-frogging" possible.

Part Two

CAVEATS, BARRIERS AND INCENTIVES

VIII. COMPUTERS AND EMPLOYMENT

174. Up until now, the present report has focused attention on why computer capability is needed for developing nations and what steps should be taken to make computers available to them. Some caution should, however, be exercised concerning the acquisition of computers, especially with regard to the talent available for operating them and their operational effect on employment opportunities.

175. The possible effect of computers and computer capability, considered as a labour-saving device, on real or imagined employment opportunities is a matter worthy of serious consideration. Computers, and especially their visible hardware component, can also be viewed both as a sign of prestige or an object of fear. To some developing nations it may also be both costly and difficult to create all the required sequential conditions such as planning, programming and skills, to utilize modern computer capability effectively.

176. The caveats against the adoption of a policy of computer acquisition by a developing nation and the employment opportunities associated with technological change in general and computers in particular are discussed in this section.

Employment and technological change

177. It is evident that technological change affects employment and one of the clearest examples is the steady decline, over decades, in the number of farm workers in North America at a time when technological change has made it possible for agricultural output to increase. But there is no simple relation between technological change and unemployment. Accepting labour productivity[18] as an index of technological change, table 3 shows the average annual percentage increase in output per worker in manufacturing industries for the period 1953-1961. During this period the level of unemployment in the United States was relatively high, at an official rate of 6 per cent. In the countries of the European Economic Community there was relatively little unemployment, while in Asia (excluding Japan) and Latin America unemployment was consistently higher than in the United States. One is forced to conclude that a high rate of technological change is not by itself sufficient to account for unemployment.

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[18] Defined as output per man-hour.

TABLE 3. AVERAGE ANNUAL PERCENTAGE INCREASE IN OUTPUT PER WORKER: MINING, MANUFACTURING, ELECTRICITY AND GAS, 1953-1961

Country	*Percentage*
Japan	6.4
East and South-East Asia (excluding Japan)	5.2
Latin America	4.2
Europe	3.6
European Economic Community	4.6
United States	3.0

SOURCE: A. J. Jaffe and J. Froomken, *Technology and Jobs* (New York, Praeger, 1968), chap. XII; the information is based on *The Growth of World Industry, 1938-1961, International Analyses and Tables* (United Nations publication, Sales No.: 64.XVII.8).

178. Besides technological change other factors also affect employment. Among the principal determinants of aggregate changes in employment are the change in demand for goods and services, the change in the labour force and the change in output per man-hour. The conclusion that technological change is only one factor in determining employment and that loss of jobs arising out of technological change may be offset by gains due to other factors has also been drawn by a number of employment studies. The European Conference of 1966 on Manpower Aspects of Automation and Technical Change give its view as follows: "On the basis of recent experience we venture to give as our opinion that with policies that are sufficiently conducive to economic growth, the dangers for employment engendered by technological advance should not be over-estimated."[19] In the United States also, the President's Committee on Automation, reporting in 1966, concluded that technological change and unemployment need not go hand in hand.[20]

179. It is not sufficient, however, to look at aggregate employment in considering the effects of technological change. Changes in technology and productivity, along with demands for new products and services have brought about substantial changes in the composition of many labour forces. Such changes have been a principal concern to the ILO and they are the subject of a series of bulletins which also documents the steps taken in many countries to mitigate the effect of changes.[21]

Job changes brought about by computers

180. There is little evidence available about the true effect of computers on employment in the industrialized nations, and even less for developing countries. Most of the accumulated evidence relates to

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[19] *Manpower Aspects of Automation and Technical Change*, European Conference, 1966, supplement to the final report (Paris, OECD publications, 1966), p. 141.

[20] *The Report to the President of the National Commission on Technology, Automation and Economic Progress* (Washington, D.C., United States Government Printing Office, 1966).

[21] *Labour and Automation*, bulletins 1 to 7 (Geneva, International Labour Office, 1964-1968).

the effects of computers on office employment, where their main impact has so far been felt. There are reports of studies in Canada, the Federal Republic of Germany, France, the United Kingdom and the United States,[22] while bulletin No. 5, entitled "Automation and non-manual workers" of the above-mentioned ILO series on labour and automation treats the question at length.

181. In Great Britain, for example, until 1964, in spite of the introduction of over six hundred computers into offices, there had been an eight per cent increase in the aggregate number of staff employed. Even if computing equipment had not been installed, it is estimated that there would have been only a 13 per cent increase. The report also predicted that there would be no dramatic change in office employment over the next five years (a prediction subsequently confirmed) and because of the time required to plan and organize a computing installation there would be adequate opportunities to redeploy staff. In view of the growing requirements for office work (2-3 per cent growth rate per year) and the slow growth in the working population, the report predicted that computers would have to be used extensively to cope with the work-load. The general conclusion was that the decrease in office jobs through the introduction of computers was balanced by the growth in need for office workers. This statement is confirmed in the ILO bulletin on automation and non-manual workers. The United Kingdom report in its final summary states: "For various reasons the introduction of automation in offices has thus far not brought about any significant dismissal of personnel nor resulted in a decline in the general level of employment of office workers".

182. Nevertheless computers are beginning to affect occupations other than those of office workers, insurance clerks and middle management. As implied earlier, some positions in process control industries are disappearing, as also are some specialized jobs such as type-setting. Industries and Governments must be prepared, therefore, to use all measures which have been developed to cope with job dislocations resulting from technological change.

183. The demand for new skills which comes with the advent of computers has been emphasized in earlier sections of this report. The need for educational and training programmes in the developing countries was also mentioned. It can now be emphasized that in addition to the requirements for skilled maintenance engineers, computer programmers and systems analysts, there are also requirements for less trained people to do operating, key punching, tape handling and data distribution. The need for persons with a wide range of skills and

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[22] J. Urvoy, "A tentative interpretation of a number of case-studies of firms and industries using office computers" (France) and J. Kruse, "Comparative manning practices in data processing installations" (Germany) in *Manpower Aspects of Automation and Technological Change*, European Conference, 1966, supplement to the final report (Paris, OECD publications, 1966); *Computers in Offices*, Manpower Studies No. 4 (Ministry of Labour, Great Britain, WMSO, London, 1965); and "Impact of office automation in the insurance industry" (Washington, D.C., United States Government Printing Office, bulletin No. 1468).

training, along with the lead time required to bring in a computer, has for most companies installing computers made possible the successful introduction of training plans which enable the machines to be staffed from within the company and often by persons whose jobs are undergoing change.

The situation in developing countries

184. The conclusions of the previous two subsections can be summarized as follows:

(*a*) In industrialized countries the experience so far has been that the introduction of computers has effects similar to those accompanying the introduction of other technological changes;

(*b*) In the conversion of office work to automatic data processing, it has been possible to carry out training programmes which at one and the same time have the effect of providing manpower for the new jobs and of finding work for those whose jobs have changed.

185. These conclusions very probably do not apply to the developing countries, because of differences in educational opportunities, mobility, job security and other socio-economic factors affecting the labour force in many developing nations. There are many factors which need to be considered before installing computers, even if funds are available and skilled programmers obtainable. Whereas high unemployment in developed countries is a possible threat which sometimes materializes, in developing countries where much of the labour force is in agriculture and process industries, both highly susceptible to automation, it is usually a chronic situation. Reducing labour costs, which might, in part, be a reason for installing automatic equipment in an industrialized country, is a disadvantage in a developing country where every change that results in a loss of jobs must be well justified.

186. For computer installations not intended primarily for education or research it is common to attempt to apply a cost-benefit analysis. In developing countries facing the decision of whether to install computers, the human and social costs of unemployment and retraining will be especially high. To install computers to do office work, process control or engineering calculations will present a particularly difficult option. Each country must therefore formulate its own guiding principles for the different situations which arise. In some cases, it will undoubtedly be considered necessary to adopt the modern processing and management techniques available only with computers. In others, it may be considered necessary to defer the introduction of computers because of employment considerations.

187. Computer technology is one of the difficult aspects of automation which will continue to confront developing countries. However, the decision to prohibit or delay the entry of computers, which on a short-term basis may have to be taken, must not be accepted as a general principle. Developing countries must place themselves in the position where they can use computers when conditions are favourable.

In view of the lead time required to educate people for and about computer use and the design of assistance programmes for equipment acquisition it would seem necessary that action be undertaken energetically and without delay.

188. The ACAST Working Group discussed the subject of computers and employment, and pointed out the shortage of data on the effects of computers on employment in developing countries (see annex II, para. 20). The Working Group expressed the opinion that the data which were available for industrially advanced countries might not be valid for developing countries. The Working Group's general conclusions were: (*a*) use of computers in new areas of activity would not displace labour; (*b*) if there is no other way to perform an essential activity, then the use of the computer may be readily justified; (*c*) the desire to be competitive in international trade may necessitate the use of computers; (*d*) computer applications which merely save labour are not recommended for developing countries. For these reasons, emphasis should be placed on the education of the labour force in computer technology.

189. The subject of the relationship of computers to employment in the developing countries cannot, however, be fully explored in this report because of the lack of sufficient information. A more comprehensive examination of the subject should be undertaken and this further analysis should also include case studies.

IX. PATENTS, COPYRIGHTS AND CUSTOMS REGULATIONS

190. Computer hardware design, where it is protected at all, is generally protected by patents. There are only a few highly developed countries engaged in the design of computer equipment. Although patents on computer hardware are important to all countries, their effects are much the same as those of other patents, and are under constant review by such agencies as the United International Bureaux for the Protection of Intellectual Property (BIRPI), the World Intellectual Property Organization (WIPO), the United Nations Conference on Trade and Development (UNCTAD) and the Organisation for Economic Co-operation and Development (OECD).

The protection of software

191. With regard to software, there is a relatively new situation arising out of the recent recognition that computer software is a distinct product. This has led to many pressures for the adoption of protective measures for computer software, from companies who market software, from customers who wish to pay only for those components they actually use, and from Governments concerned with monopolistic positions of large companies. There have been some delays in setting up protection for software, because of the previous tradition of free exchange and distribution, and because it has been difficult to determine what kind of protection, copyright, patents or contracts are most appropriate. However, now that many computer manufacturers are marketing software separately from hardware, and in view of the growing investment in software, which is said to cost more than hardware to produce, it is certain that software protection will become common, if not standard, practice, and that distribution free of charge among users and users' groups will be curtailed.

192. Assessing the relative merits of copyright and patents for protecting software is a technical matter. Patents constitute the principal method whereby most countries reward inventors. The patent is an exclusive privilege, granted to a person for a fixed term of years, to manufacture, use and sell a product or to employ a method or process. To qualify for a patent grant, the product or process must conform to certain legislative definitions of what may be patented, for example, it must be new and it must be manufactured. Copyright, the form of protection afforded, for a limited time, to creators of literary and artistic works, means that certain uses of the work (particularly copying and performance) are lawful only if they take place with the authorization of the owner of the copyright.

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193. International arrangements with respect to patent and copyright protection are the subject of various multilateral treaties; those to which the largest number of countries have adhered are, in relation to patent and copyright protection respectively, the International Convention for the Protection of Industrial Property (Paris) and the International Convention for the Protection of Literary and Artistic Works (Berne). BIRPI provides the secretariat the "International Bureau" for both the Paris Convention and the Berne Convention. Since April 1970, these duties are gradually being assumed by WIPO.

194. It can be argued that computer programs like mathematical algorithms are ideas and as ideas they are not patentable. Further, they exist in a written form as text or as recordings on a magnetic medium and hence a copyright is the natural form of protection. Even granting this, the Copyright Bureau of UNESCO has pointed out that if one tries to apply rules for the protection of photographic works to programmes recorded on magnetic tape there should be restrictions against the concept of "private use" which allows, without the author's agreement, a reproduction to be made strictly reserved for use of the person who makes the reproduction. Among the arguments for patent protection is the view that once a program is stored in the memory of a computer, it is for all practical purposes part of the hardware; also that patents are needed to protect the innovative concepts which are contained in valuable programs. There is the additional point that industry is more used to dealing with patents than with copyrights, which are usually applied to literary and artistic creations.

195. The national laws relating to patent and copyright were enacted before detailed consideration could be given to the question of possible protection of computer programs. For example, no national patent law (with the exception of that of France of 1968, which came into force in 1969) makes specific reference to computer programs. No international convention contains any reference to their protection. The courts of various countries have had to consider the application of existing patent and copyright legislation with regard to the protection of programs.

196. In some countries, particularly the United States and the United Kingdom, consideration is being given to the question in the context of a possible revision of national laws.

197. The final report of UNISIST, the project for a World Science Information System, will probably contain a recommendation on copyright law for computer programs deemed necessary for the promotion of research and culture. The issues are, however, still broader, for it is also necessary to consider how software for use in business, government and manufacturing can be made available to developing countries.

Software for developing countries

198. It is not proper to regard critically regulated patent and copyright systems as inhibitions to the transfer of technology to devel-

oping countries. The effect of patents has been examined in a United Nations study prepared in 1964,[23] where it is pointed out that the protection afforded by patents to the inventor of a device or the originator of a process encourages disclosure and licensing, making it less likely that useful information will be held secret to maintain a competitive position. Especially where this leads to manufacture in a developing country the advantage so gained offsets the imbalance of payments arising from royalties. It may be necessary to ensure that abuses, such as excessive royalty charges or a company's refusal to establish a local plant, do not take place; there are, however, corrective actions for these situations, such as the adjudication of royalty charges and compulsory licensing. Nevertheless the copyright and patent laws and the licences which will increasingly govern the exchange of software and the added requirements for foreign currencies that will follow, make it necessary to consider ways to keep developing countries from being injured by restrictions of access to these important components of the computer technology.

199. Among the ways which should be considered are the following:

(*a*) Special terms (including possibly complete waiver of patent and copyright fees) would be offered to users in developing countries. At the very least the educational allowance, which most manufacturers of computing equipment offer, might be made available;

(*b*) The costs for licensing or copyright would be covered by special aid programmes;

(*c*) Tax incentives would be offered to firms which would undertake to distribute software free or at a reduced cost;

(*d*) Regional centres would acquire software in the usual way, but would be permitted to distribute it to users who would not be required to pay extra fees. Since the task of distribution is undertaken at the regional centre, the software firms do not incur the increased maintenance costs arising out of the extra distribution.

200. In general these proposals recognize the proprietary features of software, and would not make it possible for a user to give a program to a third party except by explicit arrangement with the supplier. It is important that this proprietary feature of software be recognized in developing countries, because the hope has been expressed in several countries, in India, Israel and Japan for example, of building up a software export industry. For such an industry relatively little capital would be required, and the main need would be for a pool of people trained in thinking logically, for example in mathematics. These are available in Israel and India with its well established competence in statistical subjects; in fact many countries, which have difficulty in supporting expensive scientific research, have excellent traditions in mathematics. The lower cost of labour in these countries should, it

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[23] *The Role of Patents in the Transfer of Technology to Developing Countries* (United Nations publication, Sales No.: 65.II.B.1).

is argued, make it possible to produce software at competitive rates. While these arguments have some force, there are also counter-arguments. For one, software must be tested on computers similar to those for which it is intended, and this means that a variety of different computers will have to be available in the country. Also it is a well known fact that the costs of large software projects are very difficult to control. There seem to be several reasons for this: for instance, standard managerial techniques are not applicable (it is difficult, for example, to use them to assess productivity of intellectual efforts); or the job specification often changes and constant consultation with the client is needed. Moreover, software packages need a great deal of maintenance. It is absolutely essential to set up good mechanisms for obtaining information on defects, reporting corrections, distributing new releases and keeping close contact with actual users. All of this makes it certain that a software industry, like any component of modern technology, will be established successfully only when accompanied by very careful planning.

201. In the light of all the possibilities and needs related to the protection of computer software, it is recommended that BIRPI and WIPO with the assistance of government experts should be requested to study the following questions:

(*a*) What form of legal protection of computer programs at the national level is most appropriate, both from the point of view of the developing countries and of the producers of software;

(*b*) What new international arrangements, or modifications or reinforcement of existing arrangements are called for.

The ACAST Working Group (annex II, para. 13) suggested the convening of a meeting of experts to consider these topics.

Customs regulations

202. Another question that arises in the transfer of software between countries is whether custom dues should be paid on magnetic tapes and on other machine-readable forms of a computer program. This question was discussed by the 1967 intergovernmental conference convened by UNESCO at Geneva on the subject of material which could be classed as educational, scientific and cultural. The general position stated there was that magnetic tapes (and disks) should be treated like visual and auditory materials of a similar nature, and that subject to a certificate being provided, they should be exempt from all customs dues, quantitative restrictions and licence control. An agreement to this effect would be valuable, but it has not been reached. Even if such an agreement is obtained, there is still the question of appropriate duties for programs and data developed for commercial use. There is a need for a co-operatively developed uniform policy of customs treatment for all types of program and data and the United Nations should encourage UNESCO and other international organizations concerned with this problem to develop such a policy. Expeditious

passage of programs and data through Customs would be particularly important for regional data processing centres. Customs dues constitute only one of the ways in which restraints can be imposed on the transfer of technology. The Government of Cuba in its reply to the questionnaire has drawn attention to the boycott which applies to the marketing of computing equipment.

203. Each developing country would benefit if it were to formulate an import policy for computers and computer producers, as part of a coherent plan consistent with its national goals. All too often there are blanket restrictions against imports, or *ad hoc* rulings, which might, for example, permit a machine to be brought into a country freely, but discourage the entry of spare parts for the machine. Lessons from other import policies make it clear that developing and developed countries should attempt to determine those areas of computer technology in which they can hope to attain self-sufficiency and then adopt import (and taxation) measures which will promote growth in those areas, and at the same time, allow entry of other computer components needed to support the general technological expansion.

Standards and compatibility

204. Both in industrially advanced and in developing countries standards are desirable; if there are standards when the acquisition of new equipment is being considered, there will be competitive suppliers who can offer equipment compatible with that which has previously been acquired. For a long time in the computing industry there have been *de facto* standards, arising out of the domination of the market by a single company. Although this is better than having no standards at all, it is naturally not acceptable to other manufacturers or to computer users.

205. It is possible, however, for an industry to standardize too early. If this happens, progress will be inhibited through the inability to adopt valuable innovations because they do not conform to existing standards. It is generally felt that the rate of change in the computer technology is still so great that it is too early for the acceptance, through the International Organization for Standardization (ISO), of any large body of standards for either hardware or software. As outlined in annex 1, there continue to be fundamental developments in communication methods, terminal devices, circuit techniques and so on. At the national level, certain standards with respect to character sets and transmission devices are emerging and standardized versions of some programming languages, in particular Fortran, Cobol and Algol, are gaining acceptance. Few international standards have yet been agreed on, however.

206. Nevertheless it is desirable to promote compatibility insofar as possible. For example it should be easy to transfer data from one computer to another, and in designing peripheral equipment and proposing data formats it should be possible to write simple conversion

programs which allow this to happen. To aid the transference of software it is important to define concepts clearly so that terminology can be translated from one natural language into another, and programs from one computer language into another. Examples of useful developments along these lines are the multilingual glossaries produced by the professional societies and the MARC II record format which is gaining acceptance as a standard exchange of bibliographical information. Such developments should be encouraged in the professional organizations such as IFIP, IFAC, and the International Federation for Documentation (FID), through the appropriate United Nations organizations, including UNESCO and WMO and eventually through ISO.

X. COMPUTERS AND SOCIETY

Ambivalent feelings about computers

207. In almost any country contradictory attitudes towards computers may be found. There are reports expressing admiration of the difficult and useful things computers can do: schedule traffic, play chess or help to locate a rare blood type when it is desperately needed. Admiration may produce a genuine mystique. Because a computer is used to calculate something it is assumed that the method must be scientific and impartial; because the answers come from a computer it is assumed that they must be right. Along with accounts of the near miraculous accomplishments of computers in newspapers there are also stories of mindless stupidities perpetrated by computers, such as dumping thousands of magazines on a bewildered subscriber, or printing a salary cheque for a million dollars. And yet again there are articles pointing out how it is possible to maintain large files of personal data with the aid of computers, thereby contributing to an encroachment on personal privacy and a loss of human rights. However, the most sensitive issue involving computers is their effect on employment.

208. The mystique about computers is due in part to the aura which surrounds any major technical achievements such as the development of nuclear power or the conquest of space. Although the attitude this induces has a favourable side in that it indicates receptiveness to new ideas, there is need for restraint. For it contributes to a blind faith in the miraculous powers of science and technology which can lead people to expect too much too soon. To obtain the benefits of any new technology, including computer technology, requires a long-term development of capital and human resources. A belief that quick results are to be obtained by installing computers and pushing buttons can only delay the benefits. Fortunately professional journals on management, business, and computers, often publish cautionary articles and case histories, so that those responsible for introducing computers into government or industry have the opportunity of receiving a balanced view of the potentialities, difficulties and limitations. It remains true, nevertheless, that in assessing proposals for installing computers it is necessary to make sure that the desire for the prestige of possessing a new device has not in itself been a major consideration.

209. The ambivalence present in the minds of many about computers comes from a growing anxiety about harmful side-effects of technology in general and in particular about the possible consequences of the widespread use of computers. Even beyond the fears about unemployment it is possible to discern other fears, which are not perhaps

voiced as often or as explicitly, but which are undoubtedly present. These fears may be expressed as follows:

(*a*) The fear that man is being rendered obsolete by an intelligent, infallible device; the fear that computers are depersonalizing our society and "turning people into numbers";

(*b*) A fear that computers are propelling us towards a society run by technocrats, where important decisions are made every day by persons of narrow viewpoint who are insensitive to social and human factors and by unfeeling robots;

(*c*) A fear that computers, especially through the data banks which they make possible, will bring about an irretrievable loss of individual privacy.

Fears of computers

210. Computer programs are often said to exhibit artificial intelligence; yet when they are examined in detail it becomes difficult to understand why the term "intelligence" should be associated with them. In a well-known checkers-playing program the best move is calculated from a linear function ascribed to positions in the play, for example, material advantage, tempo or mobility. The learning which the program exhibits is simply a determination of the weight factors based on the history of play. Persons who know how the checker-playing program works may conclude that the computer does not exhibit anything which corresponds even remotely to the concept of intuitive intelligence.

211. But there are those who argue that any intelligent action, once it is dissected and understood, can be regarded as ordinary, and that computer programs which solve problems by solving a sequence of sub-problems, either by trial and error or through systematic application of an algorithm, can exhibit true intelligence, learning and adaptive behaviour. In fact, although the limits of what can be done with computers are not yet known, there are well-defined limitations to what can be expected in the foreseeable future. There has been a definite retreat with respect to language translation, and there are few who would now claim that fully automatic, high quality language translation by computers is a realistic goal. Chess play of master rank quality is not within sight. Having a machine develop abstract concepts or render aesthetic judgements appears to be an even more remote possibility. Undoubtedly the question of machine intelligence is one of the more interesting speculations about computers. But the fears of "intelligent machines", which can be found in persons who are highly educated as well as in those with little formal education, do not stand up to rational examination. Given that appropriate controls are placed on the use of computers, as on that of other technological devices, it is impossible to regard them as being in competition with human beings; or as being anything other than devices which can augment man's physical and intellectual abilities.

212. People resent the idea that they are, as it were, being reduced to numbers and holes in a punched card to meet the requirements of computer processing and this resentment has been expressed in many forms. But the increasing use of postal zone codes, social insurance numbers and account identification codes do not in themselves mean that people are being reduced to numbers. The important thing is whether society can continue to be structured so that people are treated as individuals, in spite of the rate of technological change, and it is possible to make a strong case that computers offer the best means possible of retaining individuality in a society which increasingly has to deal with large masses of people. Evidence for this has already been presented earlier. Airline reservation systems are computerized methods for recording an individual's travel plans, and even in their present form they can cope with a new request or a change of plan with remarkable efficiency. Selective dissemination of information offers listings of research articles to an individual scientist or scholar, according to his own profile of interests. Within sight are the data banks to make the detailed medical histories of an individual available on demand to doctors and hospitals. There is of course a danger in having the preferences, characteristics and history of an individual so completely and readily available from a computer. The danger is that the information about him will be used, perhaps without his knowledge, against him and will result in restrictions of freedom and rights. This real problem is discussed later. However, it is necessary to emphasize here that computers can in effective ways actually help to preserve individual identity.

213. The fear that computers contribute to the likelihood of a future society run by technocrats is understandable in view of the growing specialization of society. It cannot be dismissed; but here again the problem presented by computers must be regarded as one facet of the general problem of an increasingly complex society. Legal freedoms are not necessarily impaired because in some countries the law has become so complex that one may have to choose a lawyer who is an expert on a particular aspect of the law. Nor is health jeopardized because medicine has become specialized to the extent that a general practitioner and several specialists may be needed for the diagnosis and treatment of some illness. Individuals must continue to survive in a society where they have to call upon authoritative help in an increasing number of situations. The only solution seems to be that general education must contain enough information about specialization so that a person can know whom to turn to for advice, and perhaps be prepared to make personal judgements about those factors which concern him vitally. He must rely on the competence of specialists, and yet he must know enough about, say, law or medicine, to be able to come to some opinion about a lawyer or a doctor when it is a matter of supreme importance to him. The general education system will have to contain at least the elements of information about computers and programming, about their effects upon society and about the

mechanics of computer operation, so that persons educated in many fields—accountants, scientists and social workers—understand enough about such things not to be at the mercy of the expert practitioners when they have to make judgements about computers or about the results obtained from them. This may be difficult to achieve, but it is a challenge to educational systems and one which must be met.

Data banks and privacy

214. In some countries there is a growing concern that computers can cause an erosion of privacy and of human rights. Until recently the records kept on any individual contained data about one facet of him and were stored in a place with a definite functional responsibility. There were academic records about him in a school, medical records in a hospital, tax records in the taxation department of his Government and information about social security contributions in another department. But as seen in sections V and VI above the trend in modern government is to set up computerized data banks with records about an individual and gather them into one place. The result is that a great deal of detailed information becomes readily available about a person, information which may not always be correct and which could conceivably be used to his detriment and without his knowledge. It might be used as a basis for denying him employment, medical treatment or a passport. Few countries have a legal concept of privacy. No country as yet has laws for regulating data banks as they relate to privacy, but proposals are being considered in several. The problem is complicated because there are circumstances where highly confidential information about an individual is legitimately needed by the police or for reasons of national security.

215. The United Nations has shown an awareness of the problem in General Assembly resolution 2450 (XXIII) on human rights. This resolution invites the Secretary-General to undertake a study of the human rights problems arising from developments in science and technology, with particular reference to the privacy of individuals and the integrity and sovereignty of nations in the light of advances in recording and other techniques. The ACAST Working Group also noted the relationship of the computer and human rights (see annex II, para. 19).

216. In the consideration of what type of regulations might be adopted for data banks a number of obvious questions arise, concerning for example what kind of data may be gathered and by whom; how long data should be kept; how correctness is verified; who should have access to the data and how security should be maintained. The answers to some of these depend on technical considerations and it will probably be necessary to develop new features in computer hardware to produce satisfactory techniques. Most of the questions, however, are related to the general rights of an individual as defined and as customary in his country, and it is a matter of concern that computers should not be used as an instrument to limit these rights.

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217. It would be wrong to end by dwelling on the difficulties which can arise from the use of computers. Most of this report attests to the useful and important tasks which may be performed with computers, many of which, in fact, can only be done with computers. There is every reason to believe that the possibly harmful effects of computers can be controlled, while the benefits are retained. There is no question that the world is facing very difficult times. The benefits computers have to offer can be a powerful influence in maintaining stability until efficiency in the use of resources is increased to the point where all the essentials, and many of the so-called luxuries, are available to everyone.

Annexes

Annex I

COMPUTERS AND THEIR USES

Computer technology

GROWTH OF AUTOMATIC COMPUTING

1. The first developments in automatic computing came at the end of the Second World War. The first computers went into operation about 1950 at Harvard University and at the National Bureau of Standards in the United States of America and at the universities of Cambridge and Manchester in the United Kingdom of Great Britain and Northern Ireland. Commercial use of computers began about 1953 and since then has increased at a phenomenal rate.

2. In two decades the number of computers installed in the United States has grown from zero to over 50,000 and the annual rates of growth of the number of computers installed in the United States and Western Europe[a] continue to increase. Although there is no indication of a slackening of this increase it cannot continue indefinitely. If developing countries follow the same course, the number of installed computers will double every two to three years.

3. One estimate has been given to the effect that by 1975 the value of installed computers in the United States will have increased by a factor of 2.6 and in the world as a whole by a factor of 3 (relative to 1969).

TABLE 4. ESTIMATED VALUE OF INSTALLED COMPUTERS AT END OF YEAR, 1969 AND 1975

(Millions of US dollars)

Year	*United States*	*World*
1969	21,000-21,850	30,500-31,500
1975	54,000-54,400	92,000-96,400

SOURCE: International Data Corporation, *Industry Report*, as quoted in Organisation for Economic Co-operation and Development, *Computer Utilization in Member Countries: Examination of Surveys Carried Out in Member Countries on Computer Systems and Personnel as of October 1969*, p. 52.

4. As may be concluded from table 5, the countries with the highest gross national product make correspondingly greater use of computers. The source of the information for this table, now five years old, its incompleteness—only eleven countries being represented—and the lack of corresponding data with respect to developing countries all indicate the great need for more complete and up-to-date information.

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[a] See Organisation for Economic Co-operation and Development, *Gaps in Technology: Electronic Computers* (Paris, 1969), p. 16.

TABLE 5. INDICES OF COMPUTER UTILIZATION, 1966

Country	*Number of computers per billion dollars of gross national product*	*Number of computers per million of working population*
Belgium	16.5	79.6
Canada	18.6	132.9
France	15.3	76.4
Germany	23.0	100.9
Italy	18.7	57.9
Japan	21.5	42.9
Netherlands	19.8	89.3
Sweden	16.4	91.1
Switzerland	25.5	138.7
United Kingdom	18.8	64.8
United States	38.3	361.2

SOURCE: Organisation for Economic Co-operation and Development, *Gaps in Technology: Electronic Computers* (Paris, 1969), p. 11.

LANDMARKS IN COMPUTER DEVELOPMENT

5. The following are some of the landmarks in computer development listed in chronological order:

1950 First generation:	First computers (United Kingdom and United States) Assembly language
1953:	First commercial delivery Introduction to magnetic tape Development of magnetic core memories Computers oriented toward data processing High speed alphanumeric (alphabetic and numeric) output available
1958 Second generation:	Introduction of operating systems First user language (Fortran) Multiplicity of languages (Algol, Cobol etc.) Process control (machine tools, gasoline, cracking etc.) Transistors (increased reliability, less air-conditioning) Hardware reliability high — ceases to be measured Large disk storage
1965 Third generation:	Computer systems (hardware-operating system) Integrated circuits (more reliability, decreased cost) Multiprogramming systems Remote batch job entry Time-sharing Interactive graphics Monolithic circuits Optical character reading
1972?:	Direct execution of the user language

The first computers, designed for scientific computation, were built in university or research environments. With the first commercial deliveries the major application shifted to data processing.

6. Computer development includes: (*a*) change in hardware; (*b*) change in software; (*c*) change in organizational structure; (*d*) language development; (*e*) change in speed, reliability and unit cost; (*f*) change in capability. These changes occurred simultaneously, many of them being closely dependent on one other. Improvement in reliability came with the development of the transistor, and in view of this greater reliability, more complex systems could be designed.

CHANGES IN HARDWARE AND ORGANIZATIONAL STRUCTURE

7. In two decades since the birth of automatic computers, basic components have changed from vacuum (radio) tubes to crystal diodes, to transistors and to integrated circuits.

8. In early computers, information was stored in sound waves in a column of mercury, or as spots of charge inside a cathode ray tube (such as the tube used in television). Magnetic cores for the storage of information, perfected in 1954, shortly after the first commercial deliveries, made high speed memory systems much more reliable. Although thin film memories are becoming more competitive in performance and in cost, most high speed memories today use magnetic cores.

9. Magnetic tape for storing large files came into use at an early date; large capacity magnetic disks or drums came later. Disks improved the performance of computing systems in solving small problems and in problems involving large-scale manipulation of data. In the storage of information two terms are significant. One, "on-line storage", refers to information which is available at any time without operator (manual) action. It may be in the high speed memory, on magnetic disks or drums, or on magnetic tapes, the choice depending on how frequently the information is needed. The cost of the storage devices is inversely proportional to the access times. The other significant term is "shelf storage". Shelf storage refers to the storage information in "machine-readable form". Punched cards, magnetic tapes and magnetic disk packs are used for this purpose. Magnetic tape is most compact (in terms of characters per cubic inch); magnetic disk packs are more expensive but give better access times.

10. The most interesting and important change in the way computers are used came about with the introduction of time-sharing. The central processor operates at a rate of millions of events per second. Input and output rates are thousands of lines (or cards) per minute; the human rate is a few characters per second. This variation in data rates has been compensated for by designing systems where many users prepare programs which are submitted as a stream of jobs to the computer. Each program is executed in turn and the jobs in the output stream are separated and given back to the individual users. Systems designed to accept jobs in this way are called batch processing systems. Since, owing to their high cost or non-availability, computers were scarce, efforts were made to handle the job stream efficiently. Batch processing systems keep the hardware busy, but in doing so they keep users waiting. A different system design is to have a number of users simultaneously connected to the computer *via* low cost terminals, such as teletypewriters. This type of system gives each user in turn a few milliseconds of computing, sufficient to keep him busy. Such systems are called on-line systems or time-sharing systems.

11. Batch processing systems with their long period of development have resulted in reliable hardware and software. The good terminal hardware, secure handling of files, good user languages and operating systems which time-sharing systems need are just beginning to emerge.

12. Developments in input-output equipment and in terminals are also bringing about major changes in the accessibility of computers. The industry is expending great effort on optical character reading devices. These will read paper documents on which information has been printed, usually in a restricted set of character fonts. With some improvement in reliability and limitation in

the number of acceptable character fonts, this form of input may replace punched cards.

13. Another approach for capturing data is to use low cost terminals connected to a time-sharing system. These can be keyboards (teletypwriters) or other transducers connected directly to physical devices which are to be monitored. High speed central processors can serve a number of terminals one after another, accepting characters from or sending characters to the respective terminals, operating in an interactive mode. Still other types of terminals are cathode ray tubes, which may have light pens for writing data on to their screens. These allow data to be presented and entered in graphic form.

LANGUAGE DEVELOPMENT

14. Fortran demonstrated the importance of making computer languages easy for the user. In 1960, with the co-operation of computer professional societies a language called Algol (for algorithmic languages) was defined. Next came Cobol (common business-oriented languages). Combining some of the features of Fortran, Algol, and Cobol, PL/1 (programming language one) was developed by the International Business Machines Corporation (IBM). More recently an improved Algol, called Algol 1968, has been devised. All these languages have been called procedure-oriented languages.

15. The languages were defined and then translators were written: some were slow and generated inefficient machine code, but were later improved.

16. The standardization aspects of these languages are of interest. Fortran and PL/1 were *de facto* standards established by one computer manufacturer; the Algols were professional society co-operative efforts; Cobol was sponsored by the Government of the United States.

17. In another class, we have special purpose languages. Simscript, Simula and GPSS are designed for simulation applications; APT is a language designed for specifying machine tool control; IPL-V, LISP and SNOBOL are string processing languages for symbol manipulation.

18. Formal methods for defining languages came into existence with the definition of Algol. With the improvement in the understanding of languages and translation, programs were developed to produce translators (compilers of compilers).

CHANGE IN SPEED, RELIABILITY AND UNIT COST

19. With the shift from vacuum tubes to integrated circuits, the speed of operations has changed from microseconds to nanoseconds. At the same time users have come to realize that the basic circuit speed may not be a good indicator of computer system performance. Instead customers may develop a typical set of problems and try them on vendors' machines in "bench-mark" tests to measure the basic circuit capability, the quality of the software and the lucidity of error messages.

20. The improvement in reliability has been even more significant. At present almost all computer maintenance work is done on the mechanical parts. Card readers, printers, typewriters, magnetic tape transports and magnetic disk mechanisms, all of which involve moving parts, require most maintenance. It is not unusual for the electronic parts of a large system to fail only two or three times a year. More trouble may be expected with air conditioning and power failures than with the central processor.

21. Economics of scale apply to computers. By doubling the computer system, that is to say doubling the cost, the throughput is generally increased by a factor of four. In some situations performance falls short of this because of inadequate traffic handling facilities for input and output. Unless there are effective deterrents, users tend to use all the available facilities and to fill up the available time.

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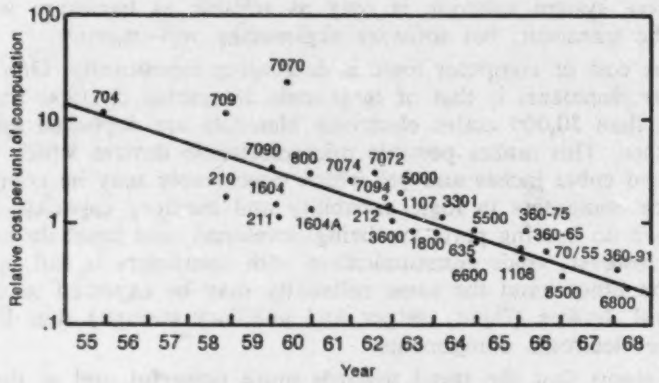
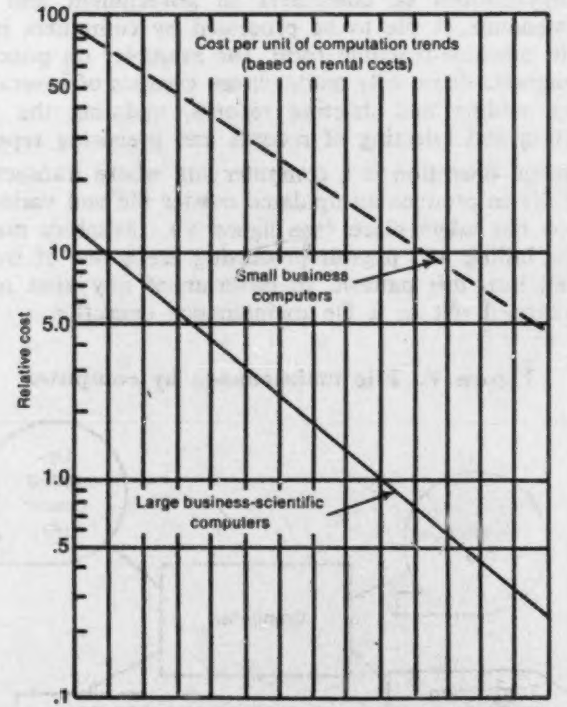
22. There has been a steady decrease in the cost of computing. Figure IV shows the trend of the cost per unit of computation based on equipment rental for large computer systems when the job mix is such that 75 per cent of the

Figure IV



Cost per Unit Computation Trend
Load Mix—75% Scientific, 25% Business



SOURCE: F. R. Heath, "Factors for evaluation of integrated on-line information systems" in F. Gruenberger, ed. *Computers and Communications—Toward a Computer Utility* (Prentice Hall, 1968), pp. 161-162. Reproduced by permission of the publisher.

work is scientific. For smaller machines, or for situations where the job mix contains more commercial work and file processing, the trend is not as steep, but there is still a steady decline with time.

PROSPECTS

23. Large system software is only as reliable as hardware was until the advent of the transistor, but software engineering will improve.

24. The cost of computer logic is decreasing significantly. One of the most significant developments is that of large-scale integrated circuits, known as LSI, where more than 50,000 active electronic elements are deposited on one square inch of surface. This makes possible microelectronic devices which occupy only a few hundred cubic inches and yet which conceivably may be comparable with large modern computers in logic capability and memory capacity. Display outputs that have no moving parts are being developed, and input devices are being simplified. However, voice communication with computers is still at a primitive stage. On the other hand the same reliability may be expected in the future in the peripheral devices (input, output and auxiliary storage) that is now to be found in the electronic components.

25. It seems that the trend towards more powerful and at the same time less expensive computing systems will continue.

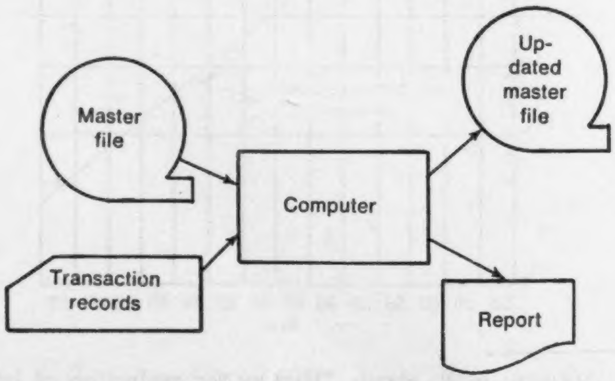
Files and information systems

FILE MAINTENANCE

26. Most applications of computers in government and business centre around file maintenance. A file to be processed by computers is a collection of records, stored in machine-readable form, for example, on punched cards, magnetic tapes or magnetic disks. File maintenance consists of several basic processes including editing, adding and deleting records, updating the file by entering transactions, sorting and selecting of records and preparing reports.

27. The central operation is a computer run where transactions are entered against a master file to produce an up-dated master file and various reports listing the activity which has taken place (see figure V). Inventory maintenance, retail accounting, credit billing and payroll processing are a few of the business applications which fall into this pattern. In government any kind of record-keeping process can be carried out as a file maintenance operation.

Figure V. File maintenance by computer



28. In developed countries these processes have been converted into computer form for several reasons: to keep costs down by reducing the number of personnel involved, to manage large volumes of transactions, and to have files

in such a form that they can be used in more sophisticated operations related to planning and management where the benefits of computers can be especially great. Even in countries where the role of private business is not so important, an examination of computer installations shows that many of them are in fact performing the work of file maintenance in a business environment. This is because the first installations are often made by foreign companies undertaking the same kind of operations as their parent company in their home country.

29. Although there may be few direct benefits to social and economic development in such installations, there are secondary advantages. Trained people, installation experts, operators, programmers, analysts and maintenance engineers are needed to work with computers and pools of such people may easily be formed in countries where there are computer installations. Furthermore the experience gained in building up and maintaining files in machine-readable form is valuable, for although file maintenance on computers is a routine task there are techniques which have to be mastered in order to accomplish it. The data going into a machine-readable file must be collected, transcribed and edited with the greatest of care, since in most cases computer programs are not able to deal with any input which varies significantly from a prescribed form. Generally, the computer operations have to be incorporated into a whole system for file handling, including preparation, processing, storage and retrieval, with the result that a highly rational approach to the function being mechanized has to be developed.

INFORMATION SYSTEMS

30. A machine-readable file is a natural precursor to an information system, a form of resource inventory which is coming to have central importance for all planning operations. There are recognizable characteristics which a collection of records has to possess before the term information system is used for it. An information system has the following properties:

(*a*) It is a large collection of records in a machine-readable form;

(*b*) Unlike a file, the system is not constructed for a single identifiable purpose, nor is it subjected to periodical processing. It will be used, rather, for a number of possibly quite different purposes;

(*c*) It is available to a large number of users who may be quite remote, and who may even use terminals connected to it by communication links;

(*d*) Accompanying the system is a set of computer programs for querying the data base, retrieving information, printing reports and so on. These programs are written in terms which will be familiar and convenient to prospective users.

31. An information system might be based on a manpower registry, a collection of medical records, an inventory of properties and buildings in a city, a comprehensive file on building materials or all the laws and legal decisions in a given jurisdiction. In important respects the system with its computer and set of programs may be compared to a service utility. Since it will be expected to have a relatively long life, and since changes can only be made after their consequences have been examined and tested thoroughly, design features such as the record format and mode of use must be thought out very carefully from the beginning. It has many remote users, some of whom come to it regularly and others only occasionally. The investment, in the form of records, operating programs and training, will be very large.

32. The Data Bank and Information System of the Bureau of Labour Statistics, Washington,[b] is an example of an information system which has had a long history of use. The basic information in this data bank, maintained by

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[b] *The Bureau of Labor Statistics Information System: Background and Principles* (Washington, D.C., United States Bureau of Labor Statistics, September, 1967).

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the Bureau of Labor Statistics, comes from the monthly current population surveys conducted by the Bureau of the Census. It provides data for individuals on such items as employment status and duration, occupation, industry, sex, age, colour, marital status, education and household relationship. In addition, summary employment statistics for local, state and federal regions, including information on hours of work, pay and labour turnover are entered. In essence, the system is a large number of time series (about 25,000) based on information related to employment. These monthly records are supplemented by others gathered on an annual basis and by various other agencies, for example, cross-section statistics on employment of scientists, engineers and technicians by occupation and by industry and information on wholesale and retail prices. There is provision for entering any type of relevant time series into the system.

33. With the system there is a problem-oriented computer language which is easily learned by the social scientist or statistician who wishes to use it. This language has terms such as table, column, series and year, which have explicit meanings in terms of the data stored. Operations such as printing a table with a specified layout or performing a multiple regression on a set of variables can be carried out by means of this language.

34. The time series information in the system covers mainly the period since the Second World War, and the system has been available for use since about 1964. An operating log-book is kept of how the system is used, which reveals the enormous breadth and depth of activity. Every month hundreds of time series for specific industries and regions are printed, scores of complex publications and analytical tables are produced and research investigations on productivity, economic indicators, and the economic structure of the country are carried out. It is for example possible to print lists of total employment and average weekly hours tabulated by city and by industry, to project employment in a given region by industry or to produce tables which show the relationship between wages, prices and productivity for fifteen major industrial sectors, defined by combining the figures for 600 individual industries. To its many users the system has been an intellect amplifier, offering the means of dealing with a large number of variables, a wide range of statistical methods and models and of testing many kinds of alternative hypotheses. It is a vital tool in research and planning, since it allows those activities to be carried out with data which are both real and reliable.

35. Recently there has been a trend towards storing information systems on-line, in what is sometimes called a data bank, or management information system. Every report on experience with on-line data banks reveals both the disadvantages and the great advantages which these collections provide or promise to provide once they are established. But any attempt to collect data from many sources and to make the various components consistent with one another and amenable to on-line computer processing invariably turns out to be more costly and time-consuming than originally envisaged. In situations where the data are graphical and not simply numerical or alphabetical, special costs for making the system operational and for maintaining it must be expected.

36. There are other problems of a political nature which can arise with information systems and data banks, especially when the information relates to individuals. In many countries there is a strong objection to having large centralized files containing comprehensive and detailed information on individuals and maintained by government authorities. These objections are based on the fear that such collections can too easily be used to limit and even destroy individual freedom. It was for this reason that a proposal to establish a national data bank in the United States was rejected after a series of congressional hearings. An initial plan for assigning a registration number to citizens in the Netherlands was also not approved.

37. Nevertheless the importance of information systems as tools for planning and development makes it certain that they will continue to grow and proliferate. Certainly systems on land resources, urban development or legislative

action will be developed in a great many places. Further demographic systems containing aggregate data on people will continue to be set up as the prime tool for social scientists and social planning. Some data keyed to individuals must be collected if a Government is to keep a census or population registry. But the limitations which should be set on systems which contain information about individuals have to be thought out more carefully. This topic is examined again in the last chapter of the present report. On-line information systems are further discussed in paragraphs 43 to 50 of the present annex.

Computers for government administration

COMPUTERS IN THE PUBLIC SECTOR

38. Every Government requires systematic maintenance of records if it is to function effectively. Examples of statistics which are basic to Governments are:

(*a*) Population and demographic records;

(*b*) Taxation records;

(*c*) Production statistics in various industry groupings, for example, agriculture, manufacturing, mining, construction;

(*d*) Economic indices, foreign reserves and trade balances, national income, private and public debt, consumer spending, average prices and earnings and the like;

(*e*) Educational statistics, including number and types of schools, teacher training, educational level attained within the population and so on.

39. At the national level, such statistics are gathered and maintained by ministries and departments set up for the purpose, such as census bureaux and departments of internal revenue; at the international level, they are collected and published by international agencies such as the United Nations, the International Monetary Fund (IMF), the World Bank and the United Nations Educational, Scientific and Cultural Organization (UNESCO).

40. Any system of maintaining records for a Government depends critically on reliable data collection. Today it is not possible to envisage acceptable methods of data collection which do not contain at least some means of recording the data in machine-readable form and of applying certain tests for reliability and internal consistency. In recognition of the magnitude and importance of this problem some Governments, particularly in connexion with their census operations, have encouraged the use of special reading and mark-sensing input devices.[c] These devices and other aspects of the automated preparation of input data and automatic editing of observations are described in a series of publications by the Conference of European Statisticians.[d]

41. Very soon, however, a country finds that it needs more than data gathering devices, or devices for preparing files. For any State which is beyond the rudimentary scale of computer sophistication, as outlined in chapter 1, computers will be needed both to process and analyze the files, and to produce results for use by national and international organizations. Thus countries even in the first stage of development need computers for public administration. For large or more highly developed countries, the point at which several and then many computers are needed is soon reached. This is not to say that computers can be introduced into the public sector without clear understanding of the procedures

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[c] The development of the Hollerith machine for sorting arose from just such an impetus.

[d] *Automatic Editing of Individual Statistical Observations, Conference of European Statisticians*, "Statistical Standards and Studies, No. 2" (United Nations publication, Sales No.: 64.II.E/Mim.34); *Automatic Preparation of Input to Computers Conference of European Statisticians*, "Statistical Standards and Studies, No. 5" (United Nations publication, Sales No.: 65.II.E/Mim.34).

to be automated, previous experience in carrying out the operations by manual methods, and intensive training and education. But given these factors, experience shows that the need to introduce computers may easily be justified, and the computers themselves soon follow. The main problem is to establish an environment in which computers can be used effectively, taking into account whatever cultural or other factors may be present.

EXAMPLES OF THE USE OF COMPUTERS IN GOVERNMENT ADMINISTRATION

42. There is probably no kind of governmental record keeping, whether carried out at a federal, state, or municipal level, which has not been converted into computerized processing somewhere, and it would be pointless to attempt to list all the applications. An indication of the extent to which computers have been adopted for almost all governmental administrative data processing can be obtained from the reply of the Government of Denmark to the questionnaire sent out in connexion with General Assembly resolution 2458 (XXIII). This reply shows that forty-five different agencies in thirteen of the government ministries are using computers. Within these agencies, some one hundred and fifty applications are identified, including the administration of construction projects, the calculation of catches for major species of fish, statistics on hospital beds, a draft register of conscripts, the analysis of passenger and goods traffic in state railways, manpower analyses, ferry reservations for cars, the novelty examination of patents, the national registration of conventions, the maintenance of an inventory of gramophone records, the administration of public debts, the drawing of premium lottery loans and the maintenance of student statistics. Even in the developing countries, where computers are relatively much scarcer, there is already a significant use of computers for government administration. This intensive use of computers is the result of a major program undertaken by the Danish Government for the creation of software for administrative use. Although many of the applications are of great interest to developing countries. it would be very difficult for any developing country to find either the resources or the skilled manpower to carry out such a program. Even in Denmark, a project of this type presents problems, because of the difficulties involved in keeping the software up to date as computer hardware and operating systems evolve. Co-operative action is needed, especially to provide help for developing countries with regard to important applications.

Planning and management applications

COMPUTERS IN PLANNING

43. The most challenging way in which a computer can contribute to economic development is as a planning and forecasting tool in operations and economic research. In one basic planning technique, computers simulate the complex situations encountered in the operation of a plant or the movement of traffic through a city, thus making it possible to identify the cause of bottlenecks or predict the effectiveness of speeding up certain phases of the operation. Special computer languages, such as GPSS, SIMULA and SIMSCRIPT, have been written for these problems.

44. A report prepared for the United Nations Conference on Trade and Development (UNCTAD) on port operations describes a typical computer simulation (TD/B/C.4/42/Add.1). The main program simulates movement of traffic in and out of the port, and there are satellite programs for the accumulation of data, the projection of future traffic requirements, the generation of traffic patterns and the printing of results. The program specifies features of the port, such as the tug and cargo sections, the queuing areas for ships, storage areas for cargo and hinterland transport and storage means and adapts these to different situations. The report describes the simulated operation of the ports of Casablanca and Vancouver. Simulations have been used to good effect

for production lines, for many other kinds of traffic, and in general, for the flow and queuing problems encountered in operations research.

45. In a model, mathematical equations are used to represent the dynamics of different parts of the system. The petroleum industry provides an outstandingly successful example, where for a long time the techniques of mathematical programming have been applied to schedule production for single refineries and refinery complexes. The economic pay-off of mathematical programming is well documented, and the use of computers for the purpose is a routine matter. In economic research, the technique of representing the economy of a country by an input/output matrix has also had wide acceptance. This matrix displays for each industry or sector of the economy the inputs necessary from all other sectors to produce a unit of output. In other economic models, time series are developed for important indices such as international capital flows, exchange rates, government revenue and expenditure. These time series have parameters which are estimated from past observations and attempts are made to project the indices into the future.[e] The Economic Commission for Europe has recognized the importance of mathematical-economic methods and computer techniques to economic research and has undertaken to co-ordinate research in this area (E/ECE/728). The World Bank also promotes and carries out research on this type of work. The analysis of investment alternatives in the Colombian transport system,[f] sponsored by the International Bank for Reconstruction and Development (IBRD) is another example of a model for a developing country. Still another example of using computers to study alternative policies for government is the *General Income-Tax Analyser*, prepared for a Royal Commission on Taxation of the Government of Canada.[g] This program is able to show the detailed implications of different taxation programmes by calculating the taxes for the various alternatives from magnetic tapes containing the necessary data on Canadian companies and individuals.

46. In spite of the undisputed success of some of the techniques described here, it is necessary to exercise caution about them. Simulations are revealing only if they are coupled with an understanding of the basic processes involved. The same is true for models. Projections based on a model become increasingly subject to error as the prediction time is extended, in part because the parameters on which formulae are based are themselves subject to change with time. All the methods depend on good data with which to calibrate the model and estimate the parameters and these may be hard to obtain. A great deal of experience is needed to know how much confidence can be placed in the results. In general, the techniques must be regarded as research approaches. Yet they hold considerable promise; the problem is how to set them up and use them in a continuing way on the problems of the developing countries.

COMPUTERS AS MANAGEMENT AIDS

47. Besides being used for operations such as file maintenance and for planning as noted above, computers have an obvious potential as management aids. The ability of computers to produce current information and reports on an operation enables managers to monitor progress, control costs and recognize when special action is needed. Network analysis methods are the best established of the techniques for managing projects. They come in a variety of forms, such as Program Evaluation and Review Technique (PERT) and Critical

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[e] N. K. Choudhry, Y. Kotowitz, J. A. Sawyer and J. W. Winder, *Trace 1969, An Annual Econometric Model of the Canadian Economy* (University of Toronto, Institute for the Quantitative Analysis of Social and Economic Policy, October 1969).

[f] *An Analysis of Investment Alternatives in the Colombian Transport System*, Transport Research Program (Cambridge, Massachusetts, Harvard University, September 1968).

[g] J. Bossons, "Studies of the Royal Commission on Taxation", No. 25, *A General Income-Tax Analyser* (Ottawa, The Queen's Printer, 1967).

Path Method (CPM).[h] The projects are represented in graphical form as a set of activities, each of which is initiated and terminated by an event. An estimate is made of the time needed to accomplish every activity,[i] and for each event an analysis is made of those activities which must be completed before it can take place. It then becomes possible to calculate earliest starting times for each event and activity, the earliest completion time for the whole project and, in particular, a set of special activities, which determine the so-called critical path which must be completed in time if the project as a whole is not to be delayed. For large construction projects computers are now regarded as indispensable and, when used as the work progresses, they provide a complete record of accomplished tasks, summaries of costs, warnings about activities not completed by deadlines and so on.

48. On-line systems for management information are file handling systems in which anyone, without knowledge of a programming language, can design, create and update files, and from them print reports in useful formats.[j] In recent versions of management systems the files are stored on magnetic disks, and they are accessible in a matter of seconds from a keyboard terminal. The system may be intended for specialized purposes, such as inventory maintenance, production control or marketing and sales analysis, or as part of a so-called total information system used to manage a business, an institution or a hospital.

49. On-line management information systems hold much promise, but they have been successful so far mainly when used in specific situations. The best known examples are the airline reservation systems which are essentially computerized systems for managing an inventory of seats. Reservation systems illustrate the difficulties, the advantages and the alternatives to computerized management systems very well. The present highly developed form has been reached only after many years of intensive development on a very large scale. It evolved through several earlier stages, and at each stage there were successively higher costs for programming, machine installation, training and operating. During the evolution a great deal of research was necessary to determine good methods of using telecommunications equipment with computers. The motives for developing the system have been partly to obtain data which would permit more seats to be sold, better scheduling, and better planning of routes, and partly to compete with other airlines by offering passengers faster, more convenient reservation service. Excellent results have been obtained, though at very high cost, and the system is a good example of a computer potential realized. It does not follow, however, that an effort such as this should be launched without hesitation in a developing country. It is quite possible to ensure the sale of a high proportion of seats by insisting, as the domestic airlines company of one large developing country does, that when reservations are cancelled adequate notice be given or a high penalty be incurred. The result is a somewhat less satisfactory service to customers, but it is legitimate, even necessary, to ask in such a situation whether the installation of a computerized reservation system would be the best way to spend capital on improving service.

50. What is needed in the developing countries is a climate in which modern management methods, including the use of computers where appropriate, are well understood and encouraged. Comparisons of factors affecting productivity in the United States and in Europe show that the existence of a cadre of professional managers in the United States is a major advantage. The lack of trained managers in the developing countries is even more serious. Today's training for management must include training with regard to computers. In the educational programmes described in this report, there are proposals for combining these complementary training efforts.

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[h] R. D. Archibald and R. L. Villoria, *Network-based Management Systems* (New York, John Wiley and Sons, 1967).

[i] In more sophisticated versions of the method, probability estimates of times and resources, in the form of manpower, funds, and the like are included.

[j] Carolyn J. Byrnes and D. B. Steig, "File management systems: a current summary", *Datamation* (November 1969), pp. 138-142.

Changing technologies

51. When computers are introduced into an area or discipline they are first used to perform specific computations, or to carry out well-defined processes. The significant change that comes about later is that the range of applications broadens and eventually very comprehensive systems emerge, capable of dealing with almost every phase of a large-scale task. At this stage, computers come to have major influence on the level and efficiency of the technology, and through it on the economic level of a country. Different technologies are at different points of the evolutionary scale of computer use. In the main, the activities associated with science and engineering, such as the construction industry, communications, the transportation technology, and the aircraft industry are at a high level, that is to say that within them comprehensive computer systems have been developed, and in some cases have been used for many years (although it does not necessarily follow that the computerized systems are used extensively). In other technologies, for example those associated with medical science, education, or information transfer, computers have so far been used mainly in individual applications and the system mode of use is just starting to emerge.

ENGINEERING

52. One highly integrated computer system, applicable to a whole industry, is the Integrated Civil Engineering System, ICES.[k] This consists of a large group of subsystems, each capable of helping an engineer to carry out a specific task which occurs as part of the design and construction of a building, bridge or highway. Subsystems are available for structural analysis and design, transportation network analysis, co-ordinate geometry calculations, bridge and road design, foundation problems, project management and control and the like. The feature which makes of this group a comprehensive system is the mutual compatibility of the representations and methods of dealing with data within the various subsystems, which allows information to be passed automatically from one to another. A feature which makes it likely that the system will have an expanding influence on the construction technology is the very general availability of the hardware and software required. A great deal of effort has been put into thorough documentation of the system.

53. The manner in which computers are affecting the teaching and practice of civil engineering, as evidenced by the experience in the United States, is itself interesting. About a decade ago, many offices recognized the usefulness of electronic computers as an aid to engineering calculations, and small machines for such purposes gained wide acceptance. This happened outside university civil engineering departments, which on the whole had not yet shown the interest in computer applications that other sectors of engineering were beginning to show. Since that time university civil engineering departments, with particular initiative at the Massachusetts Institute of Technology, have energetically adopted computer methods and the system-wide use of computers, as exemplified by ICES, is being taught in a significant number of schools. Engineering practice has not yet adopted the systems approach widely, but the fact that increasing numbers of graduates are being exposed to it probably makes it a matter of time only for the new methods to become the norm.

54. Other sectors of engineering where computers are common both in education and in operational practice are chemical engineering, where plant simulation is especially useful; electrical engineering, where computers are regularly used for design of motors, electronic circuits, antennae, and the like; and industrial engineering, where the management methods discussed previously are used. Two computer techniques coming to the fore as ways of use rather than applications associated with a specific sector are process control and computer-aided design.

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[k] B. Schumacker, "An Introduction to ICES", Civil Engineering Systems Laboratory, v. R67-47 (Massachusetts Institute of Technology, September 1967).

PROCESS CONTROL

55. Digital process computers are small machines used to control production and manufacturing process. Machines for controlling flow processes receive their input from some sensory device monitoring the process and regulate a flow, a speed voltage and the like. As yet, most process computers are found within the United States, and initially most were associated with two or three specialized industries, in particular petrochemical plants, steel mills and power distribution networks. The reasons for this relatively narrow range of use, in spite of the fact that the possibilities of computers have long been appreciated, are mainly economic. Process control computers have been expensive, costing approximately half a million dollars, and experience has shown that the savings they offer represent a very small percentage of the operational costs. This has meant that initially they were advantageous only in very large industries, where the throughput value of the product is several million dollars per year. Within the last few years, smaller and less expensive process control computers have come into the market, making it worthwhile to use them in much smaller industries. In Scandinavia and in Canada, for example, computers are appearing in mining operations and in the control of paper machines, but not as yet for controlling a whole paper plant. This trend is important for developing countries, where medium-sized plants for processing raw materials often play an important role in the economy.

56. Although modern technology is more effective in a new plant than in an old one, which may be bound by tradition and routine, it is not adequate simply to place process computers in developing centres in order to improve basic industry.

57. The international professional organization primarily concerned with digital and analogue computers for process control is the International Federation of Automatic Control (IFAC). This Federation has held four world-wide conferences as well as many conferences on specialized aspects of process control, and has an active publication and educational programme. An outline of the organizational structure and aims of the International Federation of Automatic Control is given in annex VIII.

LIBRARIES AND INFORMATION SYSTEMS

58. In all countries, scientific information systems are integral parts of the infrastructure for science and technology—as attested by the existence of VINITI, the All-Union Institute of Scientific and Technical Information in the Union of Soviet Socialist Republics, the world-wide documentation centres operated through the United Nations Educational, Scientific and Cultural Organization (UNESCO), and UNISIST, the project for a world Science Information System[l] currently being sponsored by the International Council of Scientific Unions and UNESCO. There are at least half a dozen ways in which computers are affecting the distribution of scientific information. New means of retrieving information, based on computers, are being tried in many places in the form of pilot project services offered by government institutions, scientific organizations, and private companies. Computerized typesetting has proved to be commercially successful and is likely to increase, even for the preparation of journals in mathematics or chemistry where there are highly specialized problems of display.

59. The Medical Literature Analysis and Retrieval System (MEDLARS[m]) is an early example of an index publication and literature search service based on

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[l] UNISIST, "Report of the Working Group on Scientific Information in Developing Countries" (UNISIST/WG., Dec/2.7); and A. Perez, "Plans for a world science information system", *UNESCO Bulletin for Libraries*, Vol. XXIII, No. 1 (January-February 1969).

[m] *The MEDLARS Story at the National Library of Medicine* (United States Government Printing Office 0-684850, 1963).

computers. MEDLARS tapes containing bibliographical listings for research articles in over 2,300 journals on medicine, public health and the like are prepared monthly. Search centres have been set up throughout the world for processing the tapes, and at those centres a doctor or scientist may submit a request to search for references on a given topic. The search is made by attaching to each article key words or descriptors which indicate the content. Appropriate descriptors are attached to any question posed to the system, and a search is made for articles which have descriptors matching those of the query.

60. In the initial version of MEDLARS the time elapsing between query and reply is relatively long; a new version of the system designed to reduce the delay is being implemented.

61. Many libraries have set up bibliographical files in machine-readable form for their users. The sample excerpt below shows part of the printout of a re-

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  INTERNATIONAL LABOUR OFFICE, CENTRAL LIBRARY & DOCUMENTATION BRANCH

     I.S.I.S. SEARCH NUMBER 1379                              08/10/69

                      RETRAINING SCHEMES AND PRACTICES


     29815                                                       1968
  WRIGHT HB
  SOLVING THE PROBLEMS OF RETIREMENT.
  LONDON, INSTITUTE OF DIRECTORS, 1968. 108 P.
     COMPILATION OF ARTICLES ON PROBLEMS AND /PSYCHOLOGICAL ASPECT/S
     OF /RETIREMENT/ - COVERS /PUBLIC OPINION/ OF RETIRED /OLDER
     PEOPLE/, PROBLEMS OF INCREASED /LEISURE/, POSSIBILITIES OF
     /VOLUNTEER/ WORK, /TRADE UNION/ VIEWS, /EMPLOYMENT POLICY/S FOR
     /OLDER WORKER/S, /HEALTH/, /MENTAL HEALTH/, PRE-RETIREMENT
     /TRAINING PROGRAMME/S, /RETRAINING/ OLDER WORKERS TO IMPROVE
     /EMPLOYMENT OPPORTUNITY/S, /PENSION PLAN/S, /PART TIME/ WORK,
     ETC., AND INCLUDES A /DIRECTORY/ OF AGENCIES CONCERNED WITH
     RETIREMENT PROBLEMS IN THE /UK/.
  ENGL

     29605                                                       1969
  DANSK ARBEJDSGIVERFORENING
  KVINDER PA KURSUS.
  ARBEJDSGIVEREN (COPENHAGEN), 70(3), FEB 1969, 20-21. ILLUS.
  MICROFILM
     BRIEF NOTE ON THE NEED TO ORGANISE /RETRAINING/ COURSES FOR
     /MARRIED WOMEN/ INTERESTED IN TAKING UP /PART TIME/ EMPLOYMENT -
     COVERS /TRAINING PROGRAMME/S AVAILABLE TO THE PROSPECTIVE /WOMAN
     WORKER/.
  DANI

     29595                                                       1969
  BOEKEMEIER R
  LANDWIRTSCHAFTLICHE BERUFSAUSBILDUNG NOCH ZEITGEMAESS.
  AUSBILDUNG UND BERATUNG (MUENCHEN), 22(4), 1969, 69. TABLE.
  MICROFILM
     ARTICLE SUGGESTING REORGANISATION OF /VOCATIONAL TRAINING/ OF
     /RURAL WORKER/S IN /GERMANY (FR)/ TO CORRESPOND TO CHANGING /JOB
     REQUIREMENT/S IN RESPECT OF SUCH WORKERS - COVERS THE NEED FOR
     /TRAINING PROGRAMME/S TO PROVIDE /FURTHER TRAINING/ AND
     /RETRAINING/, THE /CURRICULUM/ OF RELEVANT /TRAINING CENTRE/S,
     ETC.
  GERM

     29566                                                       1969
  DEUTSCHER GEWERKSCHAFTSBUND
  BERUFLICHE ERWACHSENENBILDUNG, D.G.B.-BUNDESARBEITSTAGUNG ESSEN
  1968.
  KOELN, BUND-VERLAG, 1969. 40 P. (ITS - GEWERKSCHAFTLICHE BEITRAEGE
  ZU FRAGEN DER BERUFLICHEN BILDUNG, BROSCHUERE 13.)
     /CONFERENCE REPORT/ ON A MEETING TO EXAMINE ASPECTS OF /ADULT
     EDUCATION/ IN /GERMANY (FR)/, WITH PARTICULAR REFERENCE TO
     /RETRAINING/, /FURTHER TRAINING/ AND SIMILAR TYPES OF /VOCATIONAL
     TRAINING/ PROGRAMMES - COMPRISES PAPERS AND RECORDS OF
     DISCUSSIONS, AND COVERS /ADULT/ /TRAINING PROGRAMME/S, /TRAINING
     METHOD/S, ETC. /CONF/ ESSEN 1968 DEC 4 AND 5.
  GERM
```

quest for information on the effects of computers and automation on manpower employment put to the Central Library and Documentation Branch of the International Labour Office; this printout was based on the machine-readable reference file there.

62. A similar service for articles on chemistry is offered on a subscription basis by the American Chemical Society.[n] This service is made to be even more useful to individual scientists or researchers by the addition of selective dissemination of information, SDI. To accomplish this an individual user provides the library computer centre with a profile, containing a list of descriptors relevant to his interests. Every two weeks, when the new chemical titles tapes are received from the American Chemical Society, the library centre processes the tapes against the profiles of their users, and prepares personal lists of new references for them. Similar services are being offered in biology, nuclear energy, space sciences, physics and an increasing number of other disciplines.

63. Still another form of bibliographical aid which becomes practical with the use of computers are the Key Word in Context or KWIC indices. These are essentially concordances of a given corpus, which may be a literary work, a list of references, the contents of an abstract journal or any similar document. Important words are marked while the corpus is being prepared in machine-readable form and the computer sorts these words alphabetically, prints a list where each word is surrounded by a small part of the text and identifies the passage where the word is to be found. The sample excerpt opposite shows part of a KWIC index prepared in conjunction with this report, for which the replies of Governments to the questionnaire, papers solicited from experts and various reports form the source material.

64. The information distribution system is an example of a technology in which computers are just beginning to exert a major influence. It cannot yet be said that the organization and working mode of existing libraries have been changed significantly by computers.[o] Most of the new projects have been directed to information services, and consideration of the requirements of the social sciences or the humanities has barely begun. It is not even known what the future will hold for libraries, either the large centralized types or those offering specialized services. In addition to those already noted, important new developments are emerging. Cameras for recording computer output directly on microfilm are being marketed extensively. With these are being developed carousels for storing large numbers of microfilm records, along with automatic retrieval mechanisms and on-line cathode-ray tube consoles from which records can be both read and written. The full impact of the introduction of computers into libraries remains to be seen. The problem so far has been that work on programs and data resulting from computer activities in different institutions have not been compatible. The emergence of the MARC II record format as a standard for communicating bibliographical information should accelerate progress towards mechanization of libraries. It is not likely that book holdings and printed records can be greatly affected in a short time. But conventional bibliographical methods, book catalogues and searching techniques will undoubtedly undergo major modification within a very few years. These developments are bringing about corresponding changes in library schools and in organizations of professional librarians. Curricula are being modified to include computer subjects, national societies of librarians are emphasizing information processing as a major component of their discipline, and the International Federation for Documentation had added educational and research projects on information systems and machine techniques to the documentation and cataloguing work which has hitherto been its major interest.

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[n] Chemical Titles Tapes, Chemical Abstracts Services (Columbus, Ohio, United States).

[o] Certain internal operations, however, such as the maintenance of the file of current holdings on periodicals, the maintenance of circulation records and the data processing involved in ordering books, are being converted to computers in large libraries.

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EDUCATION

65. The role of computers in educational data processing, as, for example, in the administrative processing of records, the maintenance of student files and projections of enrolments, is well established. Similarly it is recognized that computers are needed in schools to teach computing and data processing courses and, in North America at least, facilities are being provided for this even at the secondary school level in many communities. Formal degree courses in computer science and information processing are being established in many universities. The general subject matter of these courses includes programming, computer systems, computer design, programming language design, theory of automata and special applications such as numerical analysis, linguistics and data processing. But computers can also be used in the general teaching process and here there have been important developments.

66. Independently of computers, a method of teaching based on so-called programmed texts and teaching machines has been developed. According to this method, a body of material is presented in a sequential manner to the student, who is tested at various points and directed along different review paths according to his response. These simple teaching machines were followed by systems of computer-aided instructions (CAI), where students work at a terminal station (usually a typewriter, but it may also have audio tapes, a slide carousel and so on) and a computer simultaneously directs a number of students through the course material. With the use of computer-aided instruction, some remarkable rates of learning have been demonstrated, even where difficult material, very young students or students with learning problems are involved. Against this have to be offset the large costs for the equipment and the preparation of the curricula material in a form suitable for computer-aided instruction. Perhaps even more important, the procedures have generally been demonstrated on learning of subject material by rote, and there are no programs which can accept general response from a student.

67. In view of the current state of the art it is very dubious whether developing countries should embark on computer-aided instruction.

68. However, computers are extremely valuable, even essential, for another aspect of teaching. There are many subjects in which it is extremely useful to be able to assign problems which the student solves with the aid of computers. Obvious examples are numerical analysis, statistics and calculus. In statistics for example, the simplifications required to make a problem solvable with the use of pencil and paper sometimes lead to a loss of significant features, whereas with a computer a student can learn to deal with larger and more realistic problems. The mathematical disciplines are not the only ones where computers are highly effective in teaching. Special course materials have been developed for many branches of engineering, such as plant simulations in chemical engineering, circuit analysis and design in electrical engineering, queuing problems in industrial engineering and building design problems in civil engineering. In the social sciences there is a growing body of programs for statistics and for carrying out research on textual materials by the so-called methods of content analysis, and in the branch of linguistics known as computational linguistics computer programs for studying natural languages are being developed. In business schools there has been long experience with management games, which are simplified mathematical models of competitive business or manufacturing situations in which the students make decisions on production, marketing, research funding, plant expansion and the like, transmitting their decisions *via* the computer and receiving from it information on the success of their play. Similar games have been used for political and military learning situations.

69. Although for some teaching time-sharing terminals have been used, these are relatively expensive and it is difficult to justify their use on a large scale. Most student exercises can be carried out very well in a batch processing computer environment. To reduce the turn-around time, and make the teaching process more effective, so-called in-core compilers have been developed. These are computer languages in which the translator and the working space are small enough to be contained completely in the high-speed core storage, along with a monitor for processing a succession of jobs, and a good system of diagnostics. With such processors, small jobs can be run in one or two seconds of computer time each, and returned to the student within five minutes, all for not more than twenty five cents or so per submission. This makes it possible for even a medium-sized computer to execute thousands of student jobs per week. The result is that at present in North America and Europe, almost all university students in the science and engineering faculties make contact with computers early in their student careers, and continue to use them throughout their training, and this exposure is spreading rapidly to students in other disciplines. The emergence of many graduates who have had experience with computers is bound to have a major influence on technology.

70. The examples contained in this chapter by no means exhaust the list of areas where computers are bringing about important changes. In medicine, for example, computers are having a highly significant effect on research and science, and equally important effects on hospital administration and patient care; some day in the future, no doubt, they will even affect methods of diagnosis. In industries such as warehousing, type-setting, and machine-tooling, computers have already brought about radical changes in practices or, at least, a clear indication has been given that they will do so. It cannot with confidence be predicted of any technology that it will remain unaffected by the existence of computers in the next decade.

Annex II

REPORT OF MEETING OF THE AD HOC WORKING GROUP ON COMPUTER TECHNOLOGY FOR DEVELOPMENT

of the

ADVISORY COMMITTEE ON THE APPLICATION OF SCIENCE AND TECHNOLOGY TO DEVELOPMENT (ACAST)

Bucharest, 14 April 1970

International advisory board on the application of computer technology for development

1. The ACAST Working Group supported the proposal of the *Ad Hoc* Panel of Experts on Computer Technology that an international advisory board on the application of computer technology for development should be established by the General Assembly and recommended that the Secretary-General in his report place that proposal for consideration before the Economic and Social Council and the General Assembly. The ACAST Working Group was of the opinion that there were two broad types of function which that board should undertake:

(*a*) To promote the application of computer technology for development through international co-operative efforts in association with the United Nations family of organizations. There were a number of activities being undertaken at the present time by those organizations, but an Advisory Board could provide an impetus to those efforts and further their integration;

(*b*) To provide, upon request, independent and objective advice to assist the developing countries in their decisions on the use of computer technology for their development. A distinction needed to be made between using computer technology for specific sectoral purposes (advice on which could, for example, be provided by a competent specialized agency) and the advice to developing countries on the formulation of national policies and priorities for increasing the sound and economic application of computer technology for development.

2. With respect to (*a*), the ACAST Working Group believed that the Advisory Board should report annually to the Secretary-General who should transmit the report to the Economic and Social Council and to the General Assembly. This was desirable as the matters involved covered the broad spectrum of economic, scientific, technological, political and social aspects; required visibility and consideration at the highest policy-making level in the international intergovernmental framework; and necessitated effectively calling upon organizations in the United Nations family, members of bilateral programmes, government, industry and institutions, both public and private, and the scientific and professional community.

3. With respect to (*b*), the ACAST Working Group believed that UNDP would be increasingly involved in projects for the application of computer technology and that the Board should be used by UNDP as its advisory body on policy and as its technical review group regarding project proposals in the field of computer technology for development.

4. The ACAST Working Group endorsed the general terms of reference[a] and composition of the Board proposed by the *Ad Hoc* Panel of Experts and believed that the Board should be selected by the Secretary-General in consultation with the Administrator of UNDP. This would ensure that UNDP would also regard the Board as its own advisory machinery in the field of computer technology for development.

5. The ACAST Working Group believed that the Board would need a secretariat sufficient (*a*) to provide services to the Board itself; (*b*) to facilitate the direct advisory service activities in which the Board would be involved; (*c*) to ensure that it is fully interrelated with the requirements of the UNDP secretariat. The Board's secretariat need not be large, as it would be able to call on outside consultants and make full use of the relevant facilities and expertise of the specialized agencies and the substantive divisions of the United Nations Secretariat. Bearing in mind the two broad types of function identified above for the Board, the ACAST Working Group discussed the question of the administrative location of the Board's secretariat, the main possibilities for which were within the United Nations Secretariat or with UNDP. The ACAST Working Group concluded that careful consideration will have to be given to that question.

6. The ACAST Working Group wished to emphasize that, as it was involved in an examination of the machinery in the United Nations family for dealing with the application of science and technology for development, the proposed Board and its supporting secretariat reflected the Advisory Committee's view that the United Nations machinery must be adapted to the needs of changing technology and be able to provide the central policy role and leadership which that changing technology demanded. That was particularly the case if the developing countries were to feel that there was a focal point for efforts to encourage the realistic application of the newer technology to their development.

Regional and national computer activities

7. The ACAST Working Group discussed the degree of regional emphasis that should be contained in the Secretary-General's report. It was felt that, nowadays, most developing countries were able to afford some computer capacity, although for a number that still presented an almost impossible goal, unless assistance was given to them in an appropriate way. Regional activities should be encouraged and supported where a group of Governments indicated their wish for co-operation on that basis. The Working Group noted operational examples of activities on a regional basis such as in the fields of meteorology and international air traffic.

8. The Working Group also noted that the regional economic commissions were interested in computer development throughout their regions and was informed of the proposal before ECAFE for the establishment of a regional computing centre for Asia and the Far East (see document E/CN.11/L.249).

9. The concept of regional boards for the application of computer technology for development might similarly be deemed useful if the Governments within a region wished to establish such a regional board. In such a case, the regional board should be closely related to the relevant regional economic commission and could be a vehicle for obtaining regional judgements and expertise. Furthermore, a regional activity could provide a means for upgrading the level of competence of a national computer technology activity.

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[a] The representative of WHO requested that the reservations of his organization be recorded regarding the recommendation concerning an Advisory Board on the Application of Computer Technology for Development. It was the view of WHO that if such a Board were to be established, the terms of reference should make it clear that the co-ordination activities would apply only to the United Nations itself and not to the specialized agencies.

Intergovernmental Bureau for Information Technology— International Computation Centre (IBI-ICC)

10. The question of what might be said in the report of the Secretary-General concerning IBI-ICC was discussed. It was agreed that an essential historical description was appropriate. Since the Secretary-General was not required to give an opinion on the future of IBI-ICC as such, or to render judgement as to whether it could carry out the role it presently sees for itself, the ACAST Working Group agreed that it was inappropriate at this time to provide such opinions. That would not preclude IBI-ICC's serving as one of the sources of assistance to developing countries. The future of IBI-ICC should be determined by its own governing body.

Contribution of the private sector

11. The ACAST Working Group recommended that the Secretary-General's report discuss the role of the private sector, particularly in view of the importance of the private sector initiative in the growth and application of the computer technology. In recognition of the help of the private sector in implementing recommendations, the proposed International Advisory Board should maintain good relations with it. This might also facilitate negotiation of preferred terms for developing countries.

12. Developing countries would need an authoritative source of independent, disinterested advice in dealing with the private sector.

Legal protection of software

13. The current tendency of computer users to respect leasing agreements with regard to non-disclosure was noted. If, as expected, that led to general legal protection of software, there existed a need to examine the implications for the stimulation of flow of software for the use by and benefit of developing countries. The ACAST Working Group proposed that in the Secretary-General's report the General Assembly be requested to invite BIRPI/WIPO to convene a meeting of government experts with participation of the private sector, to examine how developing countries can best be served in the emerging situation.

Installation of previous generation equipment; computer financing

14. The ACAST Working Group discussed the desirability of installing previous generation equipment in developing countries. The Working Group found the arguments against older equipment generally convincing although it might be suitable for some particular use in certain countries. After hearing the case for and against, it agreed that all aspects of installing older equipment had to be examined carefully.

15. A similar situation obtained with respect to purchase *versus* rent of computer equipment. These options, among which should also be included another (rarely available), choice, namely the leasing of the equipment from a third party, made the financing of computers a complex subject. The ACAST Working Group believed that the Secretary-General's report should discuss the complexities involved and contain a recommendation about providing a means for developing countries to obtain advice on financing computers.

Time-sharing and computer-assisted instruction

16. The position on two technical points, time-sharing and computer-assisted instruction, was discussed. Time-sharing, it was felt, had potentialities for developing countries on condition that there were no communications difficulties. At the same time countries might develop their communications systems so that they would eventually be able to make greater use of time-sharing. A cautionary viewpoint on computer-assisted instruction was regarded as appropriate.

Levels of computer development

17. A proposal to classify the computer capability of countries in four levels, initial, basic, operational and advanced, was discussed. The intention was not to specify the levels relating to individual countries, but rather to indicate the steps which it would be necessary for a country to take in making the transition from one level to another. The approach was considered by the ACAST Working Group as being useful. A suggestion that the levels be designated first, second, third and fourth was noted.

Some general observations on the Secretary-General's report

18. (*a*) The ACAST Working Group believed that the report of the *Ad Hoc* Panel of Experts was, in large measure, responsive to General Assembly resolution 2458 (XXIII) and that the organization of the report was logical and useful. The Working Group welcomed the emphasis on education and training, which emerged as the principal conclusion. The Working Group felt that the Panel's report, with the inclusion of a suitable introduction and a detailed summary, as well as some modifications to take account of its own comments, would be in a form suitable for presentation to the Economic and Social Council and the General Assembly. In order to facilitate the analysis of the Secretary-General's report by delegations, it was recommended that the summary should follow the subparagraphs of operative paragraph 1 of the above resolution, with cross-reference as far as possible;

(*b*) The ACAST Working Group noted that it would be impossible for the Secretary-General to respond adequately to operative paragraph 1 (*a*) of General Assembly resolution 2458 (XXIII) because of the insufficiency of the information provided by Governments or of that available elsewhere. The Working Group was of the opinion that obtaining and evaluating the information called for in operative paragraph 1 (*a*) might be a task for the proposed International Advisory Board;

(*c*) The Working Group was pleased to note that the Secretary-General's report would strongly emphasize the role of international organizations, in meeting the needs for training and education for computer technology as brought out in the responses from Governments to the Secretary-General's questionnaire. In addition, the Working Group noted the large number of replies by Governments to that questionnaire (fifty-two replies received), which demonstrated the importance that Member States attached to computer technology;

(*d*) The ACAST Working Group was pleased to learn that the Secretary-General's report would contain descriptions of the appropriate computer activities pertaining to development of organizations in the United Nations family.

Computer and human rights

19. Because of its bearing on computers, reference was made to General Assembly resolution 2450 (XXIII) on human rights and scientific and technological developments. This resolution invited the Secretary-General to undertake a study of the problem in human rights arising from developments in science and technology, with particular reference to the privacy of individuals and the integrity and sovereignty of nations in the light of advances in recording and other techniques.

Computers and employment

20. The Working Group noted the shortage of data on the effects of computers on employment in developing countries and was of the general opinion that such figures as were available for industrially advanced countries might not be valid for developing countries. The use of computers in capital-intensive activities was discussed. The general conclusions of the Working Group were: (*a*) use of computers in new areas of activity would not displace labour; (*b*) if

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there was no other way to accomplish an essential activity, then the use of the computer might be readily justified; (*c*) the desire to be competitive in international trade might necessitate the use of computers; (*d*) computer applications which merely saved labour were not recommended for developing countries. The suggestion was noted that fears of further unemployment tended to occur in areas where unemployment was already high. As a consequence of the above points it was thought that emphasis should be placed on the education of the labour force.

21. The Working Group recognized that the subject of the relationship in the developing countries of computers to employment could not be fully explored in the Secretary-General's report because of the lack of sufficient information. It hoped that a more comprehensive examination of the relationship would be undertaken in a further analysis which would include case studies.

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Annex III

LIST OF PARTICIPANTS AT THE MEETING OF THE AD HOC PANEL OF EXPERTS ON COMPUTER TECHNOLOGY

New York, 24 to 27 February 1970

Members of the Panel

D. Chevion, Director, Office Mechanization Centre, and Vice-President of the International Federation for Information Processing (Rapporteur)

O. J. Fagbemi, Acting Dean, Institute of Computer Sciences, University of Lagos, Nigeria

E. Friedmann, General Manager, Empresa de Servicio de Computación Ltda., Chile (Rapporteur)

V. Glushkov, Director, Institute of Cybernetics, Ukrainian Academy of Sciences, USSR (Chairman)

C. C. Gotlieb, Director, Institute of Computer Science, University of Toronto, Canada

H. D. Huskey, Director, Computer Centre, University of California at Santa Cruz, United States

Y. A. Lecerf, Scientific Adviser of the French "Délégué à l'Informatique", and Head, Department of Computer Science, University of Paris, France

S. Moriguti, Professor, Faculty of Engineering, University of Tokyo, Japan

P. Pant, Member, Planning Commission, New Delhi, India (Vice-Chairman)

M. Parlar, Professor, College of Engineering, Middle East Technical University, Turkey

N. Teodorescu, Dean, Faculty of Mathematics, and Director, Computer Centre, University of Bucharest, Romania

Secretary

B. Barg, Office for Science and Technology, United Nations, New York

---

United Nations organizations

UNITED NATIONS

Under-Secretary-General for Economic and Social Affairs	Ph. de Seynes
Director for Science and Technology	G. B. Gresford
Public Administration Division	F. Muhammad H. Gratton
Centre for Development Planning, Projections and Policies	M. Kodikara
United Nations Industrial Development Organization	A. Aizenstat V. Krizhanovsk
United Nations Development Programme	L. A. Shapiro R. Roth
United Nations Institute for Training and Research	A. Szalai

International Labour Organisation	H. Hindle
Food and Agriculture Organization of the United Nations	J. Van Eyssen
United Nations Educational, Scientific and Cultural Organization	A. Forti
World Health Organization	W. H. Whitfield

International professional organizations

International Federation for Information Processing (IFIP)	I. Auerbach
International Federation of Automatic Control (IFAC)	H. Chestnut
Intergovernmental Council for Administrative Data Processing (ICA)	H. R. J. Grosch
Association internationale pour le calcul analogique (AICA)	E. L. Harder

Annex IV

LETTER TO GOVERNMENTS OF MEMBER STATES

1. On behalf of the Secretary-General, I have the honour to transmit to your Government resolution 2458 (XXIII) entitled "International co-operation with a view to the use of computers and computation techniques for development", adopted unanimously by the General Assembly at its twenty-third session. In operative paragraph 1, the Secretary-General is requested to prepare a report which will give special consideration to the situation of the developing countries with regard to:

(*a*) The results already obtained and the needs and prospects for the use of electronic computers in accelerating the process of economic and social development;

(*b*) The various forms which international action may take to intensify co-operation in the field of computers;

(*c*) The role which the United Nations can play in promoting international co-operation in that field, with emphasis on questions concerning the transfer of technology, the training of personnel and technical equipment.

2. Pursuant to operative paragraph 2, the Secretary-General in preparing the report wishes to consult with Member States on the task entrusted to him under the resolution. Accordingly, the Secretary-General would be grateful if he could receive relevant information, comments and suggestions on the matters raised in subparagraphs (*a*), (*b*) and (*c*) above. The attached annex may be helpful in guiding responses to this request.

3. The Secretary-General's report must be completed in time for presentation to the Economic and Social Council and to the General Assembly next year, and the size and complexity of the task necessitates following a very intensive programme of activities. To ensure that the greatest possible use is made of the responses to this request, the Secretary-General would be glad, therefore, if he could receive your Government's reply no later than 15 October 1969. A partial and preliminary reply would be useful where it is not possible to provide a comprehensive response by this date.

Guidelines to assist in responding to the request from the Secretary-General in connexion with General Assembly resolution 2458 (XXIII)

4. For the purpose of this request, computers include all means used to process data or make computations automatically. Thus, so-called unit record equipment (such as sorters and tabulators) and desk calculators are excluded. The significant criterion is that the equipment has an internal memory which can be modified by a programme.

5. In responding to subparagraph (*a*) of operative paragraph 1 of the resolution, it may be useful to provide information on the extent to which computers have been used in specialized applications that relate to the economic and social development of your country. Without being comprehensive, such specialized applications may include general economic planning, tax management, public health, statistics, demographic data, planning and inventory of natural resources, land use, urban development, communications, transportation, industrial process control and administrative data processing. Developing countries may wish to indicate if there are studies or estimates of present and

future specific needs for the next three years in applying computer technology to accelerate their economic development. Furthermore, it may be possible to indicate which factors tend to improve or inhibit the application of computer technology.

6. With respect to subparagraph (*b*), the developing countries may wish to indicate if they have been involved with international co-operative programmes related to the application of computer technology for development. Suggestions might be included for intensifying and improving the relevance and effectiveness of such programmes. Developed countries may wish to indicate what they are doing and what they propose to do in such activities.

7. With respect to subparagraph (*c*), the developed countries may wish to describe and appraise those aspects of their experience that are particularly relevant to the transfer of computer technology to developing countries. Developing countries may wish to indicate their experience in obtaining computer technology and applying it for development purposes. In particular, they may wish to provide information on the education and training in their countries in information and computer science, automatic data processing, computer programming and information handling, and to indicate whether international, regional or subregional education and training programmes are considered useful. It would be appreciated if there could be comments and suggestions on the role which the United Nations and its family of organizations could play in promoting international co-operation in the field of training of personnel and the transfer of computer technology to the developing countries. Ideas on types of assistance which will enable developing countries to build up their own capabilities for identifying their own requirements for computer equipment (hardware) and computer programs (software) may also be included.

Annex V

LIST OF GOVERNMENTS OF MEMBER STATES WHO SENT REPLIES

Australia
Austria
Barbados
Belgium
Bulgaria
Burma
Canada
Central African Republic
Colombia
Congo (Democratic Republic of)
Costa Rica
Cuba
Cyprus
Czechoslovakia
Denmark
Dominican Republic
Ecuador
El Salvador
Ethiopia
Finland
France
Ghana
India
Iraq
Israel
Japan
Jordan
Laos
Liberia
Madagascar
Malawi
Maldives
Malta
Mauritania
Mexico
Netherlands
New Zealand
Nigeria
Norway
Poland
Portugal
Romania
Sierra Leone
Singapore
Somalia
Sweden
Thailand
Trinidad and Tobago
Turkey
Uganda
United Kingdom of Great Britain and Northern Ireland
Zambia

Annex VI

LIST OF BACKGROUND PAPERS AND SPECIAL CONSULTANTS

Name	*Title of paper*
Prof. Gustavo A. POLLITZER University of Buenos Aires, Argentina	Impact of computers in Argentina, and the attitude of private sectors, the need for professional training, the universities' action, what lies ahead
Prof. L. LUKASZEWICZ Warszawa, Poland	Adapting of computers and the computer science
Prof. S. BELTRÁN Director, Latin American Institute for Information and Computing Sciences, Mexico	Application of computers and computing techniques to development in developing countries
Dr. H. K. KESAVAN Professor and Chairman, Dept. of Systems Design, University of Waterloo, Canada	Computer education in a developing country
Dr. O. J. FAGBEMI Acting Dean, Institute of Computer Sciences, University of Lagos, Nigeria	Skills in relation to educational background
Dr. S. MORIGUTI Faculty of Engineering, University of Tokyo, Japan	Computer science education
Dr. Manuel SADOWSKY Buenos Aires, Argentina	Computing and education in Argentina, Uruguay and Paraguay
Dr. V. RAJARAMAN Head, Computer Centre, Indian Institute of Technology, India	Computer science education in developing countries
Prof. F. L. T. RODRIGUEZ Montevideo, Uruguay	The role of the private sector in applying computer technology to the development of Latin American countries
Dr. John M. BENNETT Professor of Physics (Electronic Computing), University of Sidney, Australia	Roles of international organizations: University aid programs for the transfer of computer technology
Prof. A. C. OLINTO Director, Rio Datacentro, Pontificia Universidade Catolica do Rio de Janeiro, Brazil	Objective goals and role of international agencies in computer science education in Latin America
Mr. A. GERTZ Adviser on ADP to the Ministry of Finance, Jerusalem, Israel	ADP in government administration

Name	*Title of paper*
Dr. Andrei ERSHOV Computing Centre, Siberian Division of USSR, Academy of Sciences, Novosibirsk, USSR	On software compatibility
Prof. J. LIONS Directeur de Recherche, IRIA, France	Remarks on some scientific applications on computers for development
Mr. S. S. RANGNEKAR Manager, Searle (India) Ltd., Bombay-1, India	The role of private sector in applying computer technology to development in developing countries
Prof. E. FRIEDMANN General Manager, Empresa de Servicio de Computación Ltda., E.M.C.O., Santiago, Chile	Resource inventories and government planning

Annex VII

INTERNATIONAL FEDERATION FOR INFORMATION PROCESSING (IFIP)

Members

1. The IFIP was formed in 1960 and in January 1969 there were twenty-nine member countries. The full members are national technical organizations for information processing, one member per country. According to a set of statutes and by-laws, adopted in 1969, there are also associate members, individuals who are chairmen of special interest groups, and affiliate members, who may be international, professional or governmental organizations.

Objectives

2. The main objectives of the Federation are:

(*a*) To sponsor international conferences and symposia on information processing, and its mathematical, engineering and business aspects;

(*b*) to establish international committees to undertake special tasks falling within the sphere of action member societies;

(*c*) to advance the interest of member societies in international co-operation in the field of information processing.

Structure

3. There is a general assembly, consisting of representatives of the national organizations and meeting once a year, a council, an executive body and a permanent secretariat. At the technical and operating level there are technical committees (for terminology, programming languages, education, medicine), standing committees (publication, activity planning, personnel, international liaison), working groups and special interest groups. In the last-named category, the IFIP Administrative Group (IAG) is particularly active in commercial and administrative data processing and management science. IFIP is incorporated in Belgium, and has its secretariat in Geneva.

Activities

4. Since the first conference sponsored by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in Paris, 1959, there have been international conferences in 1962 (Munich), 1965 (New York) and 1968 (Edinburgh). In addition, there have been numerous symposia on education, programming languages, computer management and the like. These are organized by the technical committees, IAG and others, sometimes in co-operation with the International Federation of Automatic Control (IFAC). IFIP has acted as an official sponsor of ALGOL 60 and ALGOL 68.

5. There are complete proceedings for the international conferences and for many of the symposia. IFIP also publishes a multilingual glossary, the *ALGOL Bulletin* and (from time to time) a *News Bulletin*. IFIP has formed a committee for liaison with the United Nations and other international organizations.

Annex VIII

INTERNATIONAL FEDERATION OF AUTOMATIC CONTROL (IFAC)

Members

1. IFAC was formed in 1957. At present there are thirty-three national member organizations.

Objectives

2. The purpose of the Federation is to promote the science and technology of control in the broadest sense, in all systems—engineering, physical, biological, social or economic in both theory and application.

Structure

3. IFAC is governed by a general assembly, consisting of delegations of national member organizations, and which meets at the time of the triennial IFAC Congress. Between congresses, the work is carried out by an executive council and an advisory committee. In addition there are seven technical committees, for applications, components, education, terminology, theory, space, systems engineering. The Headquarters are in Dusseldorf, Federal Republic of Germany.

Activities

4. Four international conferences have been held in 1969 (Warsaw), 1966 (London), 1963 (Basle) and 1960 (Moscow). In addition, many technical symposia on special topics have been held throughout the world, under the auspices of the technical committees often in co-operation with IFIP. In 1968, the following symposia took place:

April: "Pulse rate and pulse-number sequels in automatic control" (Budapest).
June: "Digital control of large industrial systems" (Toronto, held in collaboration with IFIP).
June: "Optimal systems planning" (Cleveland, United States).
August: "System programmes and automatic control in basic industries" (Sydney, Australia).
August: "System sensitivity and adaptivity" (Dubrovnik, Yugoslavia).
September: "Technical and biological problems of control" (Yerevan, USSR).
October: "Hazard and race phenomena in switching circuits" (Bucharest).
October: "Multivariable control systems" (Dusseldorf, Germany).
November: "Fluidics" (London).

Full proceedings have been published for the congresses and most of the symposia. In addition, there is the *IFAC Information Bulletin*, the *Multilingual Dictionary of Automatic Control Terminology* (published in six languages) and a technical journal, *Automatica*, which is published by-monthly.

5. A special IFAC *Ad Hoc* Committee on United Nations Computer Usage in Developing Countries has been formed to co-operate with the United Nations.

Annex IX

THE INTERGOVERNMENTAL COUNCIL FOR ADMINISTRATIVE DATA PROCESSING (ICA)

Members

1. Members of ICA are informal country representatives responsible for central government information processing. There is one representative per country. Delegates from sixteen countries have participated in ICA conferences and working contact is maintained with seventeen other countries.

Objectives

2. The organization concerns itself with the problems of central government information processing, and the relation between central administrative data processing authorities and other levels and sectors of government activity. Among the subjects which come within the scope of ICA are:

The place of administrative data processing in governmental organization
Long-range planning
Procurement of computing facilities
Implications of standards and standardization
Manpower requirements, recruitment and training
Integrated management information systems for central Governments (including administrative data banks)
Population registration systems
Social implications of computing
Relationships with legislatures
Government auditing
The impact of administrative data processing organizational patterns (centralization, decentralization and computing networks).

One of the explicit objectives of ICA is to co-operate in the development of administrative data processing in less experienced countries.

Structure

3. The ICA is governed by a council consisting of the national representatives, with a chairman, vice-chairman and secretary-general as officers. The secretariat is maintained in Israel.

Activities

4. The organization arose out of the Symposium on Automation of Population Register Systems held in Israel in September 1967. Since then there have been conferences in Edinburgh (1968), Oslo (1969) and Jerusalem (1970). The activities to date have mainly taken the form of an exchange of information at the conferences.

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Printed in U.S.A.
23130—December 1970—5,400

Price: $U.S. 2.00
(or equivalent in other currencies)

United Nations publication
Sales No.: E.71.II.A.1
E/4800; ST/ECA/136